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ENVIRONMENTAL MANAGEMENT OF FISH RESOURCES IN THE BLACK SEA AND THEIR RATIONAL EXPLOITATION

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ENVIRONMENTAL MANAGEMENT OF FISH RESOURCES IN THE BLACK SEA AND THEIR RATIONAL EXPLOITATION

by

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ABSTRACT

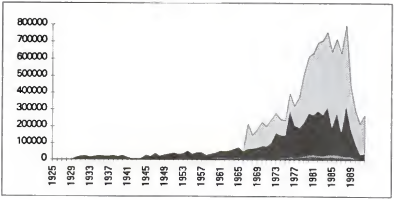
After a short introduction describing the environmental status of the Black Sea, information is presented on the marine algae, and the phytoplankton and zooplankton, including the events following the introduction of the predatory ctenophore, *Mnemiopsis leydei*. The existing historical information available on the resources of more than 14 commercial fish in the Black Sea is summarized, and placed in context with information on the marine environment together with an evaluation of the impact of environment changes.

CONTENTS

I. INTRODUCTION

During the last 30-35 years the Black Sea ecosystem has been subjected to dramatic changes due to the increased pollution of the basin and the over-exploitation of some commercial fish species. The period of "eutrophicated sea" dates back to the early 1970s and is characterized by structural and functional alterations in the ecosystem as a result of the intensification and spreading of both local and regional phytoplankton blooms. These blooms over the last decade attained their maximum intensity in late spring-summer, an abnormal period for the Black Sea where peak production normally occurs in early spring and autumn. Changes have also been registered in the taxonomic composition of blooms - since 1989 producing phytoplankton species with succession shifted towards the predominance of Dynophyta - towards an increasing importance of Crysophyta species - *Emiliania huxley* and *Phaeocystis pouchettii* (Monchava, 1991a and b). Recently some phyto- and zooplankton species new to the Black Sea ecosystem have invaded the basin resulting in dramatic alterations in the food web (Monchava *et al.*, 1993). During the period under consideration the abundance of the most commercial carnivores has sharply decreased - bonito (*Sarda sarda* Bloch), blue fish (*Pomatomus saltator* Linnaeus) and mackerel (*Scomber scombrus* Linnaeus). The last species has nearly disappeared in the Black Sea since 1968. This has been the period of rapid intensification of fishing particularly of sprat (*Sprattus sprattus phalericus* Risso), horse mackerel (*Trachurus mediterraneus ponticus* Aleev) and anchovy (*Engraulis encrasicolus ponticus* Aleksandrov) for which catches have been extended from 3.1, 4.9 and 128.3 thousand tonnes (1970) up to 105.2 (1989), 147.7 (1985) and 485.5 (1984) thousand tonnes, respectively. Shlyakhov *et al.* (1990) claim that the rapid decline of anchovy stock could be related both to the deteriorated environmental conditions and the overfishing during some years. In the early 1980s (1982) the ctenophora *Mnemiopsis leidyi* = *Mnemia mccradyi* invaded the Black Sea (Zaitsev, 1993; Konsulov, Konsulova, 1993) with a biomass resulting in several-fold reduction of the zooplankton biomass; copepod species in particular (Vinogradov *et al.*, 1989; Zaika and Sergeeva, 1991; Schushkina, Nikolaeva and Lukashova, 1990). Taking into account the fact that *Mnemiopsis leidyi* is feeding on eggs and larvae of spawning fish although at a less significant rate (Erameev and Chudinovski, 1990), it is reasonable to assert that the sharp reduction in sprat, anchovy and horse mackerel stocks could be related mainly to the complex impact of the four above-mentioned factors -pollution, eutrophication, structural alteration in the ecosystem and intensification of fishery. **Figure 1** gives an estimation of the total Black Sea catches. It can be seen that after 1988 the catches sharply decreased for the mentioned species.

The four factors are of anthropogenic origin and should be discriminated from the natural factors such as global climatic changes in particular and their impact on hydrology and hydrochemistry of the basin and its primary production (Bryantzev, 1989). A typical example in this sense is the established periodicity in qualitative and quantitative composition of phytoplankton in the Black Sea in respect to the solar activity variability (Petrova-Karadjova and Apostolov, 1988; Petrova-Karedjova, 1993). Another natural and anthropogenic factor is the registered decline of water exchange of the Black Sea. This was related to the lower river inflow. Hence, the global climatic changes through the overall amount of reinfall also exerts an influence on the river inflow. As is well-known the water exchange is one of the main factors conducive to water cleaning by oxidation of organic matter. According to Ress (1987) this is the reason why bonito and blue fish avoid Black Sea waters, although their stocks in the Sea of Marmara have not decreased. Berenheim (1960) estimated that the outflow of the Black Sea waters through the Bosporus during the 1960s and earlier, ranged within 397-400 thousand cubic kilometres, and the inflow from the Sea of Marmara - within 175-193 thousand cubic kilometres. During the 1980s the respective values were 340 and 176 thousand cubic kilometres (Sorokin, 1982), i.e. the outflow of the Black Sea waters has dropped by 57-60 thousand cubic kilometres. That is why the expected decline of rainfall at the end of 20th century will increase the effect of pollution of the Black Sea waters. All this calls for annually revised stock assessments and catch projections of commercial fish species in relation to the environmental conditions.



* Without Turkish catches for the period 1925-1966

Figure 1a. Total catches (in tonnes) by countries in the Black Sea

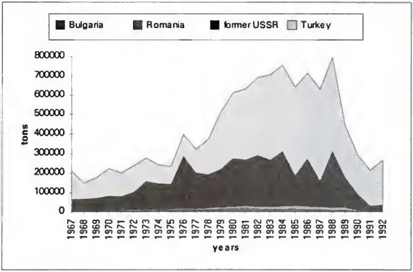


Figure 1b. Total catches (in tonnes) by countries in the Black Sea

II. ENVIRONMENT

The Black Sea is situatad between latitudes 40°55'N - 46°37'N and longitudes 27°27'E - 41°47'E. Its maximum length is et 42°29'N latitude - 620 miles - and meximum width et 31o27'E longitude - 332 miles. The greatest depth is 2 258 m. The general characteristics of the basin are the following (**Teble 1**):

TABLE 1. Generel characteristics of Bleck Sea

Isobaths (m)	Area (km^2)	Volume (km^3)
0 - 25	16930	212
25 - 50	30937	1160
50 - 100	49057	3679
100 - 200	15399	2310
200 - 500	14284	4999
500 - 1000	22592	16944
1000 - 1500	38490	48113
1500 - 2000	69195	121091
over 2000	156604	331446
Total	413488	529954
According to Zaitsav (1993)	423000	534000

The shelf surface area of the Black Sea is 96 914 km^2 (23.44% of the total eree). Out of it 43 960 km^2 (10.63%) ere in tha territory of Ukreine, 10 680 km^2 (2.58%) in Russia and Georgia, 10 700 km^2 (2.59%) in Bulgaria and 31 574 km^2 (7.64%) in Turkay and Romania.

On the basis of tha morphologicel peculiarities of the shelf and the continentel slope the Bleck Sea cen be conditionally seperated in 8 regions: 1. North-wastern; 2. South-western; 3. Turkish; 4. South-eestern; 5. Caucasian; 6. Kertch-Temansky; 7. Crimean; 8. Central. Through the Kertch Strait it communicetes with the Sea of Azov and through the Bosporus with the Mediterranean.

The Black Sea is a semi-closed basin with raletively greet depths, smell connection with the World Ocean, and high bioproductivity of the shelf zone - 242 tonnes of phytoplenkton par km^2. Here discherge some big rivers like the Danube, Dneister, Dneiper, South Bug etc., which determines the lower salinity of Black Sea waters compered with those of the Mermara and Aegean Seas and Mediterranean.

The specific structure of the Black Sea was noted at the beginning of the oceanographic investigations of the basin: first of ell, the existence of two layers, highly different with respect to the hydrological parameters end divided by e constant picnocline (helocline). The occurrence of hydrogen sulphide at depths of more than 125-224 m is another important peculiarity since surface weters setureted with oxygen represent only 12% of the totel water volume. Tha daap (below 100 m) remain relatively isolated from the surface layer, where aerobic processes take place. For this reason, below the basic picnocline layar (en anoxic zone) is formed, preceded by an oxygen deficit zone, where the organic matter is oxidized to sulphetes and by enaarobic bacterial reduction tha sulphates are reduced to hydrogen sulphide.

Tha geostrophic circulation in the surfece leyer of the basin is presented by tha **Mein Bleck See Stream (MBS)**, which ganerates extensive cyclona gyras in tha central aest end western regions and a multituda of smaller cyclones end enticyclones (**Figure 2**). At the externel part of the **MBS**, due to its intaraction with the continental slope, e ring of anticyclona gyres is formed, which ganeretes a quasi homogenous **Convergence Zone (CZ)**.

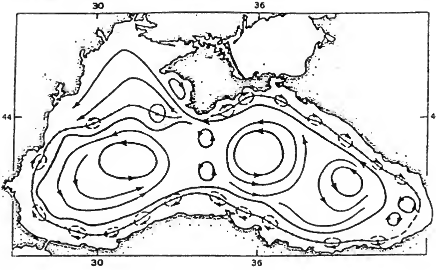


FIGURE 2. Surface circulation in the Black See (from Practical Ecology, 1990)

Despite the existence of the constent picnocline, recent studies show that the water column has an intensive vertical dynamic, especially in winter. The strong North end Northeast winds elevete the mein cyclonic gyres domes (to 20-30 m from the surface in some areas), which breaks apart the picnocline and laads to increasa of tha convectiva mixing with 0.02 cm/s avaraga spaad (Ovchinnikov and Popov, 1987). In this **Divergence Zone (DZ)**, formed in such e way over an area of 40 000 km^2, ebout 3-4 000 km^3 as en average deep weter's upwelling, exceeds 10 times the voluma of the river inflow (Vinogradov *et al.*, 1992). The deep waters, shifted to the surface, mix with the coolad surface layer in a 1:5 retio and initiate the so callad **"Cold Intermedieta Layer" (CIL)**, typical of the thrae layer summer hydrostructure. The **CIL** forming cold weter, downwells from the picnocline domes, to the periphery of the cyclone gyres until it reaches the **MBS**, which spreads it throughout the basin.

The upwalling of water in tha **DZ** of tha central part of the basin is compensated by its downwelling in the **CZ** above the continental slope, which coincides with **CIL** downwelling to the periphery of the cyclone gyres (Ovchinnikov *et al.*, 1991). The downwelling in **CZ** watar is compensated by intensification of the **DZ** upwelling as well as by tha actively upwelling of water on the continantal slope in the coastal zona. Coastal upwelling is noted in soma araas, dua to tha influence of tha geomorphologic particuleritias of tha coast and bottom and the local winds (e.g. **Cape Keliekre**: Dimitrov *et al.*, 1987; **Odesse Bey**: Vinogradove and Vassileva, 1992; **Peninsule of Crimea**: Bletov end Ivenov, 1992).

In winter, due to the impact of the low tamparatures end the strong winds, the shelf zone is subject to intensive vertical mixing, which covers the total water column, from the surface to the bottom. In spring tha surface layer warms up end a seasonal thermocline is noted in the 25-30 m leyer. Thus, the typicel the werm season, e three leyer structure is observed in the open Sea,

comprising an upper quasi-homogenous layer, with lower limit at the seasonal thermocline, a 6-8°C cold intermediata layer between the saasonel thermocline and the constant picnocline, and an anaerobic zone below the picnocline. At this stratificetion, the vertical mixing is negligible: 1-1.6 x 10^{-7} cm/s (Boguslavsky *et al.*, 1979).

In tha north-wastarn part of the Black Sea the summer vertical stratification is still better expressed owing to the influence of river inflow. The Danube waters form a vast frontal zone which spreads its influence over the whole western coest as far as the Bosporus (Rojdestvensky, 1954).

In summer the thermocline lies at dapths of 25-30 m. Here inner waves ere generated that form gyres in the proximity of tha shelf zone, promoting vertical water axchange as well as the uptaka of nutriants from daap waters euphotic layers (Kitkin, 1953; Bogdanova, 1959).

The temperature regime of the Black Sea is typical of temperete latitudes. The thermohaline structure of the offshore zone eccording to average date of Sorokin (1982) is shown in **Teble 2.**

TABLE 2. Thermohaline structura of the Bleck Sea offshore zone

Depth (m)	Water tamperature (°Ñ)	Salinity ($^0/_{00}$)	Oxygen concentration (mg/l)	Hydrogen sulphide concentration (mg/l)
0	22.1 (7.1)*	18.24 (17.44)	5.6	0.0
10	22.1 (6.8)	18.34 (17.60)	6.7	0.0
20	15.7 (6.8)	18.40 (17.80)	7.4	0.0
30	9.3 (6.7)	18.93 (18.10)	5.8	0.0
50	7.7 (7.6)	19.80 (18.40)	5.4	0.0
100	8.1 (8.1)	20.63 (20.28)	0.8	0.0
150	8.4 (8.5)	21.01 (20.95)	0.2	0.15
200	8.6	21.34	0.05	0.75
500	8.9	22.05	0.0	5.15
1000	9.0	22.31	0.0	8.27
500	9.0	22.35	0.0	9.41
2000	9.1	22.36	0.0	9.21

* - in brackets, the values of the parameters during winter are shown

During winter tha surface water leyers in the north-western and north-eastern part of the see cool to 0°C. In summer they warm up to 24-27°C in the inshore and to 21-23°C in tha offshore zone.

The water balance of the Bleck Sea is neer equilibrium (**Table 3**). The prevailing portion of the river runoff is due to the Danube river - about 2 000 km^3 per year.

The ionic composition of the Black Sea waters is similar to the oceanic (in %), except for the carbonic ion, the latter having in the Black Sea concentration substantially higher, especially in the deep layers (Skopintsev, 1975) (**Teble 4**).

The specific characteristics of the hydrochemical and hydrological structure of the Black Sea have set their imprint on the biota species composition as well as its abundence.

TABLE 3. Water balance of the Black Sea

Inflows - sources		Outflows - sources	
according to Solyankin (1963)		according to Solyankin (1963)	
river inflow	246	evaporation	332
atmospheric rainfall	129	outflow in	
inflow from		the Sea of Azov	32
the Sea of Azov	53	outflow in	
inflow from		the Sea of Marmara	340
the Sea of Marmara	176		
Total	704	Total	704
according to Rojdestvensky (1978)		according to Rojdestvensky (1978)	
river inflow	294	evaporation	301
atmospheric rainfall	254	outflow in	
inflow from		tha Sea of Azov	29
the Sea of Azov	38	outflow in	
inflow from		Sea of Marmara	485
the Sea of Marmara	229		
Total	815	Total	815

TABLE 4. Ionic composition of Black Sea waters

Ions	Black Sea		Ocean
	0 - 300	300 - 2000	
Cl^-	55.230	55.250	55.200
Br^-	0.183	0.185	0.190
SO_4	7.540	7.410	7.690
CO_3	0.460	0.950	0.200
Na^+	31.360	31.230	30.590
K^+	1.020	1.070	1.100
Ca^{2+}	1.310	1.280	1.200
Mg^{2+}	3.240	3.740	3.720

The phytoplankton comprises 746 species, 525 of them being marine or brackish, 211 - freshwater or brackish , plus 10 species undefined in relation to salinity preference (Pitsik, 1979) - **Table 5**. In this list the new species that invaded the Black Sea during the last years are not included since their taxonomic position is not finally specified.

TABLE 5. Number of phytoplankton species in the Black Sea

Taxonomic groups	Sea and brackish waters Genera	Sea and brackish waters Species	Fresh and brackish waters Genera	Fresh and brackish waters Species	Grand total Genera	Grand total Species
Bacillario-phyta	55	245	24	93	64	342
Pyrrophyta	34	193	6	12	36	205
Chryso-phyta	25	47	2	3	27	51
Chloro-phyta	11	23	26	66	36	91
Cyano-phyta	5	8	10	24	12	34
Xanto-phyta	3	6	-	-	3	6
Eugleno-phyta	3	3	6	13	7	17
Total	136	525	74	211	185	746

The mean annual phytoplankton biomass varies considerably during the years (**Table 6**). The phytobenthos consists of macrophytes, sea grass and microphytes. This is the group mostly investigated off the Romanian coast where 388 species have been found (Bodeanu, 1979) (**Table 7**).

TABLE 6. Phytoplankton biomass in the Black Sea

Years	North-western part	Eastern part	Years	North-western part	Eastern part
1960	-	36	1975	484	194
1961	1008	42	1976	672	1120
1962	696	29	1977	1533	1130
1963	-	45	1978	786	356
1964	722	100	1979	1921	405
1965	741	42	1980	2170	505
1966	511	120	1981	940	617
1967	512	134	1982	733	1369
1968	282	120	1983	933	256
1969	464	96	1984	918	418
1970	806	78	1985	201	180
1971	369	88	1986	381	136
1972	520	135	1987	557	346
1973	1621	114	1988	821	300
1974	1082	261	1989	988	-

TABLE 7. Number of macrophytobanthos species (Bodeenu, 1979)

Taxonomic groups	Marine	Marine and brackish	Breckish and fresh-watar	Fresh water	Grand total
Bacillario-phyte	171	76	58	48	353
Pyrrophyte	13	1	-	-	14
Chlorophyta	2	-	4	2	8
Chrysophyta	6	-	-	-	6
Cyanophyte	5	-	1	-	6
Euglenophyta	1	-	-	-	1
Total	198	77	63	50	388

Tha annual microphytobenthos production is estimeted to be around 15 million tonnes, the total biomass being 0.2 million tonnes. Ivenov and Beverton (1985) geve for the seme peremeters, velues of 54.5 and 0.5 million tonnes, raspectively.

According to Kalugina - Gutkin (1979) the number of mecrophytobenthos species is the following (**Teble 8**):

TABLE 8. Numbar of macrophytobenthos species in the Black Sea

Seeweed groups	Merine	Brackish and marine	8rackish	Fresh weter and breckish	Grend totel
green	31	42	7	5	85
brown	62	15	-	-	77
rad	112	28	1	1	142
Total	205	85	8	6	304

The Phyllophores end Cistozeires ere the dominent elgee genere. In this view the vast maadow of rad algaa ("Zarnov's phyllophora field") is unique in tha world. It is situated in tha north-western part of tha Black Sea at depths of 30-65m, between 45-46°N and 30-32°E. In the eerly 1960s-1970s the total biomass was astimeted at 7-12 million tonnes. As a result of eutrophication and pollution of the besin the phyllophora biomass steedily decreased (**Teble 9**).

Tha figures in brackets ara according to data from "Commarcial description of tha 8lack Sea" (1988), the others ara according to tha ennual reports of YugNIRO (Ukraine). In spite of some apperent differences in the point estimates (owing to different surface areas investigated) they reflect as a whole rather well the negative changes in the phyllophora biomass - the decline was around 21-36 fold in reletion to the period 1960-1970. Ivenov and Beverton (1985) drew the seme conclusion end noted that its totel biomass hes diminished from 6.6 to 2.5-3.0 million tonnes in 1974.

The total phytobenthos biomass has been estimated to be about 15 million tonnes and tha production eround 50 million tonnes, which represents ebout 3% of the overell production of organic metter in the Black Sea (Mashtakove, Rouhyanen, 1979; Hydrometeorology and Hydrochemistry, 1992). According to Ivanov and 8everton (1985) the macrophytobenthos biomass is 16.0 million tonnes and thet of the production 17.6 million tonnes. Consequently, the total phytobenthos biomass is 16.5 million tonnas and tha production 72.6 million tonnas.

TABLE 9. Surface area (km^2) and Phyllophora biomass (x 10^{-3} tonnas) during the period 1972 - 1993

Years	Araa (km^2)	Biomass (x 10^{-3} tonnes)
1972	(1185.8)	(1868.4)
1973	no data	no data
1974	no data	no data
1975	(523.2)	1200.0 (983.8)
1976	no data	no data
1977	(355.9)	(976.9)
1978	?	1080.0
1979	(368.2)	1000.0 (143.6)
1980	(491.6)	790.0 (260.9)
1981	(440.8)	910.0 (223.0)
1982	no data	no data
1983	(110.4)	350.0 (258.2)
1984	(37.2)	790.0 (179.9)
1985	(38.2)	430.0 (122.2)
1986	?	580.0
1987	?	450.0
1988	?	340.0
1989	?	250.0
1990	no data	no data
1991	no data	no data
1992	?	300.0
1993	?	320.0

The zooplankton comprises basically 98 specias. This figure may be increased to 120 specias bacausa of the Mediterranean immigrants, soma of them having succeeded to adapt to the Black Sea environment. Besides, in spring and summer about 20 species (Mollusca, Polichaeta, Crustacea and other benthic and nektonic organisms) enrich the plankton community with their larval stages (Sorokin, 1982). **Table 10** shows the taxonomic composition of the primary zooplankton according to Grese and Fedorina (1979).

TABLE 10. Taxonomic composition of zooplankton in the Black Sea

Taxonomic groups	Family number	Genera numbar	Species number
Tintinoidea	4	9	25
Hydrozoaria	9	10	10
Scyphozoaria	2	2	2
Ctenophorae	1	1	1
Rotatoria	4	9	35
Cladocera	2	4	8
Copepoda	9	13	15
Chaetognatha	1	1	1
Appendicularia	1	1	1
Total	33	50	98

The zooplankton species have different origin and hence different ecology. The major part is concantrated in tha upper 50 metre-layer (Nikitin, 1945; Hydrometeorology and Hydrochemistry, 1992) and the low border of distribution in the zones of circular streams lies at dapths 175-200 m (Nikitin, 1949). In the cantral halistic parts, the lower border may rise up to 85-100 m. After Vinogradov *et al.* (1987) this border of zooplankton occurrence is datarminad by the dissolved oxygen concentration and not by tha incidence of hydrogen sulphide.

According to Gresa and Fedorina (1979) the zooplenkton biomass of the different taxonomic groups is as follows (Tebla 11):

TA8LE 11. Zooplankton biomass in the 8lack Saa

Taxonomic group	Biomess in wet waight th. tonnas	%	Dry weight in % to wet weight	8iomass in dry weight th. tonnes	%
Crustacea	2820	18.0	17.0	479.4	56.0
Noctilucaa	5540	35.3	2.0	110.8	12.9
Ctanophoraa	5335	34.1	2.3	122.7	14.3
Sagittae	424	2.7	4.7	19.9	2.3
Madusaa	675	4.3	0.13	0.9	0.1
Othar	878	5.6	14.0	122.9	14.4
Overall	15672	100.0	-	856.6	100.0

The indicated figuras should be observed es meen values, es fer es the zooplenkton biomess differs in wide bounderies during the verious yeers (Teble 12).

TABLE 12. Zooplankton biomess in layars 0 - 100m (mg/m^3)

Yeers	Eastern pert of 8lack Sea	Wastarn part of 8lack Sea	Avarage	Years	Eestern part of 8lack Saa	Western part of 8leck Sea	Avaraga
1964	60.7	177.6	119.1	1979	64.8	69.8	67.3
1965	54.5	108.9	81.7	1980	113.2	225.1	169.2
1966	86.0	78.5	82.2	1981	118.1	67.3	92.7
1967	133.1	275.6	204.4	1982	43.9	58.2	51.0
1968	107.0	90.4	98.7	1983	69.5	43.9	56.7
1969	80.5	170.9	125.7	1984	85.3	42.5	63.9
1970	-	89.0	89.0	1985	73.9	77.8	75.8
1971	110.3	141.5	125.9	1986	58.3	87.8	73.0
1972	84.9	60.3	72.6	1987	77.3	36.5	56.9
1973	161.4	84.4	122.9	1988	84.5	46.9	65.7
1974	99.4	115.8	107.6	1989	113.3	50.3	81.8
1975	61.1	82.2	71.6	1990	76.8	70.8	73.8
1976	46.9	47.9	47.4	1991	29.6	75.9	52.8
1977	43.8	44.1	44.0	1992	75.8	48.0	61.9
1978	26.8	61.4	44.1				

Tha sama is valid for tha annual production, which varies from 90 to 120 million tonnes (Hydrometeorology and hydrochemistry, 1992), the last corresponding to 246.6-328.8 thousend tonnes daily production. The ennuel production of Sagitte is estimeted to be about 31.7 million tonnas, and tha daily products about 87 thousend tonnas.

According to Ivenov and Beverton (1985) the ecological factor used to datarmina the various trophic lavals (Ka) is too low for the detritivore orgenisms end cernivores, 0.067 end 0.003 raspectivaly. Tha abova-mantionad authors axplain tha lattar with tha fact, that tha mussals being e mein consumer of detritus, are not aeten by other orgenisms. The extremely low level of utilization of tha trophic bese by predetors is expleined es due to negligibla use of plenktonic predetors such as jelly-fish, Ctenophore, Segitte, atc. , higher in tha food chain.

The introduction (1982) and tha mess development of the new species Ctenophore (*Mnemiopsis leidyi = Mnemia macradyi*) after summar 1988 caused significant changas in all trophic

levels of the Bleck sea ecosystem. Observetions in experimentel (equeriums) end neturel conditions show that the mentioned species consumas tha native spacies Ctanophora (Plaurobrachia), its own genaration, fish-aggs and larvae of fishas but mostly copepoda (Vinogredov *et al.*, 1989; Vinogredov end Shushkina, 1992; Melishev end Archipov, 1992). In experiments it is proved thet the food needs of this predetor ere extremely high (to the complete filling of the stomach). As a result, the biomass of Copepoda end Cladocera, according to differant authors, decreesed (in the layer 0-25m) from 6 to 8 times in comparison with the mean long-term summer zooplankton biomess (Malishev, Archipov, 1992); from 10 to 20 times (Lipskaie, Luchinskeie, 1990) end from 10 to 30 times (Vinogradov *et el.*, 1989). According to Bulgerian data (Atanasova, Velikova, Manesiava, in press) tha summer end autumn zooplenkton biomasses had decreased 5.7 and 3.8 times respectively in comperison with the period 1974-1987 end 11 end 6 fold during the period 1954-1973. The population explosion of ***Mnemiopsis*** and the following reducing of the remeining zooplankton is a normal process for the West Atlantic, from where this species is transferred. The mess development of it is due to its cepability to inemineta itself, to its high fertility, eccalereted rate of growth end high survival of the generetion (to 10%) Reeve end Welter (1978); Miller (1974). In this connection the ***Mnemiopsis*** cen successfully combet most of its competitors, but for the seme reeson it cen with difficulty, keep its biomass et e high level (Kremer, 1976). That is why its biomess veries within wide bounderies depending on the food cepecity of the water body. According to different authors in the period 1989-94 the Mnemiopsis' biomess variad from some thousand of million tonnes to some ten of million tonnes.

Heving in mind the estimates of zooplankton production (of crustaceans as a main food) we shell indicate only those of Grishin, Kovelenko end Sorokolit - JugNIRO (personel communicetion - the full text of their report will be given in press after improving the estimetes for 1993 and 1994) (**Teble 13**).

According to Vinogradov *et el.* (1989) Mnemiopsis biomass has reached 700 million tonnas.

TABLE 13. Biomess of jelly-fish end the naw species Ctenophore (x 10^{-6} tonnes) during April-May and June -July (by data of Sorokin and Sorokolit YugNIRO)

Years	Biomass of jelly-fish IV-V	VII-VIII	Biomess of Mnemiopsis VII-VIII
1976	7.1	69.5	
1981	10.7	91.5	
1982	32.3	48.4	
1983	5.4	41.5	
1984	7.7	45.4	
1986	4.6	12.3	
1987	4.6	12.3	
1988	5.4	4.6	
1989	6.1	5.4	33.7
1990	2.3	5.4	30.7
1991	0.8	6.2	40.5
1992	0.8	2.3	18.9
1993			10.0
1994			40.0

The zoobenthos of the Black sea is represented by 1518 species (without Protozoe), from which 156 ere found in river estuaries end freshwater, end 85 - in the Bosporus region (**Teble 14**). The deepest layer of distribution is ebout 125-130 m, in the Bosporus region - 170-200 m. Only some Nemetoda from the ganus Desmoscolex, Trocome end Cobbioneme ere found in depths from 200 to 600m, in the permenent anoxic zone (Zaitsev *et el*, 1987). The mentioned eerobic orgenisms exist in the aneerobic zone due to its ability to use the accumulated carotinoides (in sediments) as e source of oxygen.

TABLE 14. Texonomic groups of Zoobenthos in the Black Sea

Taxonomic groups	Overall species number	in brac-kish waters	at tha Bospo-rus	Taxonomic groups	Overall species number	in brac-kish watara	at tha Bospo-rua
Foraminifara	26	-	-	Scaphopoda	1	-	1
Spongia	28	-	-	Ostracoda	109	16	11
Hydrozoa	25	3	-	Harpacticoida	154	3	-
Anthozoa	5	-	-	Cirripedia	5	-	-
Turbelaria	103	-	-	Amphipoda	103	38	-
Namertini	33	-	-	Isopoda	29	-	-
Nematoda	240	-	-	Tanaidacaa	6	-	-
Rotatoria	40	21	-	Cumacaa	23	9	-
Gastrotricha	23	-	-	Decapoda	32	1	-
Kynorhyncha	10	-	-	Aracina	27	3	-
Polychaeta	182	3	30	Pantopoda	8	-	-
Oligohaata	39	23	-	Insacta	11	7	-
Sipunculidae	1	-	1	Tardiyrada	5	-	-
Bryozoa	18	-	-	Ustaroidaa	1	-	1
Camptozoa	2	-	-	Ophiuroidaa	4	-	3
Phoronidae	1	-	-	Echinoidea	1	-	1
Loricata	3	-	-	Holothurioidea	8	-	3
Bivalvia	88	12	20	Ascidiae	8	-	-
Gastropoda	118	17	16	Total	1518	156	87

Most researchers accapt that tha pariod of autrophication began in the aarly 1970s. This period wes characterized by structural and functional changes in tha Black Sea acosystem, in consequence the locel end globel "blooms" of phytoplankton became more frequent, more continuous and covared a largar araa (Prodanov, Dancheve, Ivanov, 1993). Besidas the "blooms" ere often followed by oxygen deficit end death of bottom and near-bottom organisms (Salsky, 1977; Zaitsev, 1977 - according to Zaitsav, 1993; Moncheva, 1991, 1992; Monchava, Patrova-Karadjova and Pelasov, 1993; Konsulova, Konsulov and Moncheva, 1990; Konsulova, 1991 - in prass), aspacially in the narrow shore zone. In soma ceses even the pelagic species, such as anchovy and horsa mackerel, are baing influenced by tha hypoxia (Zaitsev, 1993). According to the same author, the surface of the tamporary acting anaerobic zones shows a tandancy to increase (**Tabla 15**).

TABLE 15. Tha surface araa of anoxic zone (x 10^3 km^2) in tha north-western part of the Black Sea

Years	Surfece aree	Yeers	Surfece area	Yaars	Surfece eree
1973	3.5	1979	15.0	1985	5.0
1974	12.0	1980	30.0	1986	8.0
1975	10.0	1981	17.0	1987	9.0
1976	3.0	1982	12.0	1988	12.0
1977	11.0	1983	35.0	1989	20.0
1978	30.0	1984	10.0	1990	40.0

According to Zaitsev (1993) biological losses from e hypoxia over an 18 year period (1973-1990) are estimated over 60 million tonnas, including 5 million tonnes of fish (young end adult individuals).

During the period considarad tha anthropogenic pollution of the Black Saa hes incraasad meny times, the besin being historicelly burdened with a larga anaerobic zone, as a result it has a small capacity for assimilating pollutants. That is why in Black Sea bottom fishas ara rarely found to 100 m dapth and pelagic and naar-bottom fishes to 100-130 m (Prodanov, Dencheva end Ivanov, 1993).

The catchmant araa of the Black See is ebout 22 times greater than its surface. This is one of the main reasons for the quick contamination of the sea, in a consequence of intensification of industry and agriculture after 1960. By the end of the 1980s the river outflow to the sea annually has contained ebout 4-5 km^3 weste waters (ebout 5% of the total river inflow). Into the shelf zone enter annually an averaga of 400 thousand tonnes of bioganic substances, 410 thousand tonnes of petroleum products, 20 thousand tonnes of detergents, 700 tonnes of phenols. In eccordance with the data of the State Hydrometeorology Service of the former USSR in 1970 (by Danube river) by the rivers in the Bleck See have penetreted 2.7 thousend tonnes nitrites end 16.5 thousend tonnes phosphates, and in 1979, corraspondingly 13.5 end 27.0 thousend tonnes. Besides 180 thousand vessels with a total displacement of 12.5 million tonnes, coming through Bosporus, hava polluted the sea additionelly with about 12 thousend tonnes petrol (personal communicetion - academic Jakovlev - Director of JugNIRO). Similer estimetes ere given by Konovalov (1992). According to this euthor the Bleck Sea is polluted annuelly with about 100 thousend tonnes petroleum products, from which 40-50 thousand tonnes come through the Danube. The pollution of the sea with heavy metals and other chamical compounds (Marine Pollution '90, 1990) is considerable.

By the Denube into the Black Sea entar annually 60 tonnes mercury, 240 tonnes cadmium, 4000 tonnes lead, 900 tonnes chrome, etc. In relation to cuprous Black See is more polluted then the Mediterranean (2-3 times). The pollution of the see with verious chemicel compounds (DDT, PVC, etc.) is very significant. Through the rivers Danube, Dnapr, Dnastr and South Bug into Black Sea come annually about 1200-5000 tonnes. According to UNEP most dangerous for the living orgenisms are the isotopes of radium, other nuclear fission products and mercury, followed by the pasticides, heavy metals, etc. (UNEP, 1986a, b, c; 1987). In comperison with the Mediterraneen and Baltic seas, Bleck See is considerebly more burdened by phosphates, nitrates, especially if having in mind the eneerobic zone. According to Konovelov (1992) these amounts are as follows: (**Table 16**).

As it is known, the most importent influence on the merine ecosystems belongs to the phosphetes, nitratas and calcium compounds that are the reason for growing old of water bodies (Vollenweider, 1976). Most influencad in this connection is the north-westarn part of the Black Sea, as far es by the abova-mantioned rivers comes into the see a great amount of nitrogen and phosphorus, which are transferred to the Bulgarian coasts by the currents characteristic of this ragion. In this connection the Bulgerien zone is more polluted by waters from the north-western part of the sea then from its own pollutents, for the exception of some coestel regions (near Varna and Burges).

TABLE 16. Amounts of phosphates and nitrates (in tonnes per km^2) in the Bleck See, Mediterranaan and Beltic Sea

Chemical compounds	Black Sea	Maditerranean	Baltic Sea
Phosphetes	153842.5 0.286 (2.85*)	384606.0 0.102	82415.0 3.8 (0.19*)
Nitretes	437.5-875.0 8.1-16.2**	1093.0-2187.0 0.291-0.582	234.4-468.0 10.85-21.0

Note: * -the predicted value for the amount of phosphorus in the Baltic sea is in accordance with the international programme for control over phosphates, coming into see (Internationel Programme for phosphorus control on the Baltic).
** -the emounts of phosphorus and nitrogen ere calculated for the volume of the aerobic zone of the Black see.

The intensification of fishery after 1976, particularly the late forbiddance of bottom trawl-hauls, which ruined the bottom biocenosis and spoiled the connections between bottom and pelagic waters, influenced negatively the state of the Black sea ecosystem. Schematically represented the most important changes which happened are the following:

- quantitative and qualitative decreasing of microphytobenthos, especially in the north-western part of the sea;
- increasing of continuity, intensity and regularity of "blooming" of phytoplankton;
- reducing of biodiversity, concentration and biomass of zoobenthos, as a result of regular and mass death, following, as usually occurs, the "blooming" of phytoplankton, as well as the mass development of new species, mainly the *Rapana thomasiana*, which is a predator of the black mussel *Mytilus galloprovincialis*. The concentrations of Rapana fell down many folds after its mass catch began, which was a favourable condition for increasing the biomass of the black mussel;
- the increasing of concentration and biomass of some stable species zoobenthos, mainly Polychaeta and Nematoda, is not able to compensate the dropping down of the total biomass, because besides the decreased biomass of the black mussel (in the 1960s it is about 10 million tonnes in the north-western part of the sea) the oyster *Ostrea edulis*, which abundance by the end of the 1950s was 50 million individuals almost completely disappear (Zakutski and Vinogradov, 1967);
- changes in the concentration and biomass of some zooplankton species. The domination of species as *N. miliaris*, *A. clausi*, *P. polyphemoides* is a fact, indicating eutrophication of the sea;
- sharp reducing of biomass of small zooplankton (Copepoda), which is a basic food, either for planktivorous fishes or for the larvae and the juveniles of the other fish species;
- sharp decreasing of the concentration and biomass of most of the fish populations, especially the summer spawned pelagic species: anchovy and horse mackerel.

As it is already known, many fish species in the Black Sea undertake seasonal migrations for nourishing, wintering and reproduction, and on this account the pollution of the sea or the over fishing by any Black Sea country (mainly Turkey and the former USSR) leads to the total reduction of concentration and biomass of the corresponding species.

This defines the necessity to generalize the data of all Black Sea countries, for the purpose of distinguishing the influence of anthropogenic factors (including the fishery) and the so-called natural factors - global climatic and cosmic processes. For example, according to Petrova-Karadjova and Apostolov (1988), the biodiversity and the quantitative development of various phytoplankton groups depend on the solar activity. These changes in the trophic basis also influence the survival of new generations, and consequently affect the state of the stock of the corresponding species in the following years.

The Black sea is inhabited by 168 species, from which 144 are typically marine ones, and 24 diadromous or partly anadromous. Along the Bulgarian coast, as a result of a detail studying the ichthyological bibliography, 126 species of marine and diadromous fishes are indicated (Prodanov, Dencheva and Ivanov, 1993). The classification of fishes is given according to the modification done by Rass (1987).

From the marine species the objects of intense fishery are sturgeons, shad, anchovy, sprat, horse mackerel, whiting, gobies, turbot, spiny dogfish, Mugilidae, bonito, bluefish, mackerel, etc. Up to the beginning of the 1970s, bonito, blue fish, mackerel, which as from 1968 was already not found in the Black sea, for the exception of the Bosporus region, represented a certain importance from an economic point of view.

As it was pointed out (**Figure 1**), after 1979 the fish catches in the Black Sea sherply increased, reeching 797.5 thousend tonnes in 1988, then dropped egein to 216.5 thousand tonnes in 1991. In 1992 they had a slight tandency to increase. The accidental decraase of catches after 1988 is meinly due to summer spawning fish species (anchovy end horse meckerel), in connaction with the massive development of new species Ctenophore, which biomess wes very high in 1989. For other fish species the negative chenges are not so obviously expressed, end for some of them, as for the shad (data in advance), even an increase of catches is observed. In this connection we shall consider more pracisely the commercially valuabla fish species, their stock dynamics and the causes, which determine it, as well.

III. STOCK ASSESSMENT OF COMMERCIAL FISH SPECIES IN THE BLACK SEA

SPINY DOGFISH, *SQUALUS ACANTHIAS* LINNAEUS

The spiny dogfish, *Squalus acanthies*, is wide-spread in the Atlantic, the Mediterranean and the Black Sea, where a specialised fishery is carried out for this species.

Table 17 shows the landings by countries during the period 1967-1992. Total catches have ranged from 191.1 (1967) to 12 296.1 (1979); on average 4 011.5 tonnes. The greatest amounts are taken in Turkey whose average catch of 2 800.8 tons represents 69.82% of the total. The next country is the former USSR with 1 159.9 tonnes (28.91%). From the pointed out figures it is evident that the Bulgarian and Romanian yields are insignificant - 26.3 (0.66%) and 24.5 (0.61%) tons, respectively.

TABLE 17. Spiny dogfish catches (tonnes) in the Black Sea during 1967-1992

Year	Bulgaria	Romania	Former USSR	Turkey	Total
1967				191.1	191.1
1968				797.9	797.9
1969				207.3	207.3
1970				521.2	521.2
1971				2585.1	2585.1
1972	20.0		606.0	2081.6	2707.6
1973	9.0		1515.0	443.1	1967.1
1974	1.0	6.0	1000.0	1346.1	2353.5
1975	4.0	6.0	636.0	0.0	646.0
1976	4.0	3.0	1400.0	1178.4	2585.4
1977	18.0	1.0	1300.0	1214.3	2533.3
1978	21.0	4.0	1400.0	1127.9	2556.9
1979	6.0	3.0	1400.0	10887.1	12296.1
1980	10.0	3.0	1700.0	4702.0	6419.0
1981	27.4	8.0	1500.0	5602.0	7137.4
1982	20.0	19.0	1700.0	6750.0	8489.0
1983	52.0	93.0	1600.0	7161.0	8906.0
1984	53.2	134.0	1500.0	4588.0	6275.2
1985	67.5	77.0	2100.0	2598.0	4842.5
1986	152.6	52.0	2100.0	2581.0	4882.6
1987	90.3	49.0	1800.0	3139.0	5078.3
1988	50.9	25.0	1900.0	3261.0	5236.9
1989	27.7	30.0	300.0**	4558.0	4915.7
1990	16.4	45.0	1700.0	1059.0	2820.4
1991	16.0*	26.0	1500.0***	2017.0	3559.0
1992	16.0*	53.0	1500.0***	2220.0	3789.0
Average	26.3	24.5	1159.9	2800.8	4011.5
%	0.66	0.61	28.91	69.82	100.00

* Bulgarian catches in 1991 and 1992 are set at 6 tonnes but probably were considerably larger. After 1989 no fishery statistics data were available, so the latter is adopted as possibly its lowest level.

** Former USSR catches for 1989 after Ukrainian data are 300 tonnes.

*** According to Kirsonova (1993) catches by Ukraine and the former USSR during the period 1983 - 1992 varied between 1500 and 2200 tonnes.

During the last 10 years the price of spiny dogfish grew rapidly, which led to heavy fishing of this species. For lack of effective control, the prevailing quantities from tha cetches ere not reported in the fishery statistics after 1989 for Bulgaria and Romania, and to some extent for Ukraine and the other former Soviet countries. All this hinders precise stock assessments, especielly during the last few years. However, tha Black Saa spiny dogfish has a long life span which is the reason for the smaller fluctuetions in its biomass.

Teble 18 presents the ege composition of the total catches, based primarily on Ukrainian data.

TA8LE 18. Age composition (x 10^{-3} specimens) of spiny dogfish catches during 1972-1992

Year	4	5	6	7	8	9	10	11	12
1972	0.28	1.93	2.85	5.04	6.68	12.98	24.26	30.05	55.46
1973	0.06	0.41	0.65	1.15	1.48	3.28	6.59	8.49	42.15
1974	0.18	1.24	1.84	3.26	4.30	8.48	16.02	23.07	45.13
1975	0.00	0.00	0.00	0.05	0.10	0.15	0.38	0.88	4.36
1976	0.15	1.08	1.61	2.85	3.78	7.19	14.06	20.59	38.89
1977	0.16	1.12	1.65	2.99	3.99	7.76	14.88	29.02	52.20
1978	0.15	1.04	1.54	2.79	3.67	7.50	14.39	23.70	47.83
1979	1.45	10.03	14.85	25.98	34.00	65.52	121.90	141.90	258.50
1980	0.65	4.35	6.43	11.31	14.73	28.69	54.00	68.70	129.60
1981	1.23	4.37	3.27	4.35	9.21	22.70	23.35	61.90	44.30
1982	2.30	6.92	20.83	51.87	46.98	134.20	73.16	48.80	117.90
1983	1.44	18.71	20.83	38.20	14.00	108.50	66.25	84.54	207.10
1984	0.31	2.22	2.93	5.96	7.61	9.92	6.96	19.18	73.65
1985	1.16	4.86	6.87	28.05	8.64	33.59	29.86	60.94	132.98
1986	1.16	2.63	12.83	13.13	12.78	66.02	34.82	52.96	78.46
1987	0.60	2.10	9.70	9.18	12.35	69.95	33.31	40.35	98.14
1988	0.86	3.68	18.35	28.65	53.73	190.40	120.50	104.30	121.30
1989	0.86	4.01	4.38	7.13	12.86	51.31	24.06	28.58	55.49
1990	0.28	2.32	5.40	6.12	10.83	38.72	26.73	38.41	50.72
1991	0.94	6.02	3.66	2.25	3.71	14.86	17.77	9.71	49.73
1992	1.03	7.76	15.78	20.12	6.83	26.97	45.93	52.47	37.83

TABLE 18 - continued

Year	13	14	15	16	17	18	19	C_N	W (g)
1972	92.44	76.96	78.16	32.03	10.85	1.66	0.41	432.11	6.27
1973	60.91	57.32	62.33	29.39	13.42	1.13	0.09	288.85	6.81
1974	77.51	67.29	70.38	30.53	11.87	1.40	0.27	362.77	6.49
1975	10.20	19.09	18.77	21.04	10.39	5.11	0.37	90.89	7.10
1976	74.43	78.71	100.21	47.63	16.54	1.61	0.23	409.56	6.31
1977	92.84	69.48	71.75	37.41	15.28	2.56	0.26	403.35	6.28
1978	83.45	74.58	79.31	35.65	14.86	1.51	0.22	392.19	6.52
1979	426.70	347.70	348.10	137.80	42.35	7.58	2.15	1986.51	6.19
1980	217.60	182.90	180.60	77.41	27.10	3.89	0.93	1008.89	6.36
1981	406.60	276.90	171.40	50.19	16.92	2.73	0.00	1099.42	6.49
1982	208.90	178.00	293.80	135.80	18.10	6.33	1.21	1345.10	6.31
1983	580.40	274.10	131.80	4.78	14.26	0.00	0.00	1564.91	5.69
1984	295.70	209.20	239.60	55.01	3.75	1.37	0.00	033.37	6.72
1985	135.36	135.15	129.65	56.67	24.14	1.53	0.08	799.53	6.13
1986	169.30	181.70	90.91	60.78	19.65	1.65	4.36	823.14	6.05
1987	95.74	167.20	182.50	57.51	16.36	10.15	0.00	805.14	6.31
1988	110.10	119.80	89.74	43.13	10.79	4.44	0.00	1019.77	5.14
1989	154.70	120.40	181.20	78.11	18.88	6.34	0.00	755.31	6.51
1990	87.43	48.46	109.50	31.92	8.03	2.44	0.00	467.31	6.04
1991	96.18	52.99	133.63	96.11	29.74	8.77	3.29	529.36	6.72
1992	59.87	65.63	46.19	79.63	48.12	11.53	3.96	549.65	6.89

Spiny dogfish ageing is done using the spines (Ukraine) end aga raadings are quita unrelieble. For this reeson only dete on catch size composition for the rest of the countries during certein years wera evailabla. For thesa yeers the siza - ega composition key prepared by Ukrainian collaagues was used and for other years, the aga composition of the former USSR catches only.

As a species with a long life span the spiny dogfish has a low natural mortality coefficient, being highest in the first year of life and lowest when attaining sexual maturity. According to Kirnosova (1990), tha values of M, at tha avarege for both sexes (by aga groups), era as follows: (**Table 19**).

TABLE 19. Natural mortality coefficients (by age groups) of spiny dogfish

Age	M	Age	M	Age	M
4	0.24	10	0.07	16	0.42
5	0.20	11	0.05	17	0.60
6	0.14	12	0.09	18	0.92
7	0.12	13	0.16	19	2.84
8	0.10	14	0.49		
9	0.09	15	1.51		

According to this author the high netural mortality of tha 15 yaar old fishes is attributad to the great mortality rete of the males for which this is the definitive ege. The same applies to the femalas but at aga 19 yaers. As with many other fish species, the lower survival of males is due to the eerliar atteinmant of sexuel meturity - et age 10-11 yeers, whila famales stert spewning at ege 13-14 years. At thesa egas their values of M ranged from 0.03 to 0.05.

Kirsanova and Shlyakhov (1988) found that the spiny dogfish exploited stock comprises fish from 8 to 19 years. The younger age groups inhabit areas where no trawl fishery is carried out. Therefore, the trawl surveys covering the shelf area account only for the older age groups in the exploited stock. The Turkish size compositions show that irrespective of their inconsiderable quantities, fish at age 4-7 years are available in the catches. For these ages the following values for partial recruitment to the exploited stock (after Ukrainian data) were adopted:

TABLE 20. Partial recruitment of spiny dogfish exploited stock

Age	Partial Recruitment	Age	Partial Recruitment	Age	Partial Recruitment
4	0.056	10	0.745	16	1.000
5	0.142	11	0.837	17	1.000
6	0.245	12	0.918	18	1.000
7	0.375	13	0.973	19	1.000
8	0.500	14	1.000		
9	0.640	15	1.000		

Table 21, 22 and **Figure 3** show the results of VPA performed by tuning of F_{st} for the oldest ages. From **Table 21** and **Figure 3** it is seen that the exploited stock has gradually increased till 1981 when it reached its maximum of 226.7 thousand tonnes and then slowly decreased to 90.0 thousand tonnes in 1992. The level of the mentioned stock was in accordance with that of its preys - whiting, sprat, anchovy and horse mackerel. The biomass of these species were at their maximum in 1978-1981 except for that of horse mackerel whose peak was in 1983-1985.

TABLE 21. Stock assessment (x 10^6 specimens and x 10^3 tonnes) of spiny dogfish in the Black Sea during 1972-1992

Year	4	5	6	7	8	9	10	11	12	13	11	15	16	17	18	19	$Å_{4\text{-}19}$
1972	9.479	27.018	6.365	4.647	4.840	4.181	2.625	2.442	2.341	1.420	1.101	0.661	0.174	0.039	0.007	0.008	79.3
1976	19.868	7.456	22.119	5.531	4.117	4.373	3.809	2.424	2.294	2.086	1.125	0.615	0.113	0.089	0.014	0.002	85.9
1976	16.712	15.629	6.104	19.229	4.904	3.724	3.994	3.545	2.297	2.056	1.722	0.645	0.110	0.051	0.039	0.005	95.6
1975	13.464	13.146	12.795	5.305	17.051	4.433	3.395	3.708	3.349	2.056	1.681	1.003	0.113	0.047	0.020	0.015	133.4
1976	19.306	10.591	10.763	11.123	4.705	15.429	4.052	3.165	3.527	3.057	1.743	1.015	0.214	0.058	0.019	0.005	143.0
1972	19.597	15.187	8.670	9.355	9.863	4.254	14.094	3.764	2.991	3.186	2.536	1.007	0.182	0.102	0.020	0.007	166.0
1976	12.666	15.416	12.433	7.536	8.295	8.920	3.880	13.127	3.552	2.684	2.629	1.500	0.192	0.090	0.045	0.006	184.2
1979	14.945	9.963	12.620	10.807	6.681	7.502	8.146	3.604	12.463	3.201	2.210	1.553	0.298	0.098	0.039	0.017	198.4
1980	11.230	11.755	8.148	10.958	9.561	6.013	6.794	7.477	3.290	11.144	2.335	1.087	0.203	0.088	0.024	0.011	210.2
1981	4.242	8.834	9.620	7.078	9.708	8.637	5.468	6.282	7.045	2.883	9.295	1.289	0.166	0.072	0.029	0.000	226.7
1982	7.262	3.336	7.228	8.360	6.273	8.775	7.872	5.076	5.915	6.397	2.083	5.480	0.213	0.069	0.028	0.010	220.9
1983	4.448	5.711	2.725	6.265	7.366	5.632	7.892	7.269	4.781	5.594	5.258	1.139	1.087	0.036	0.000	0.000	206.4
1984	5.422	3.497	4.659	2.350	5.520	6.652	5.043	7.294	6.832	4.172	3.977	3.010	0.197	0.710	0.010	0.000	203.6
1985	10.695	4.265	2.861	4.047	2.078	4.989	6.070	4.695	6.920	6.174	3.282	2.275	0.564	0.086	0.387	0.003	186.4
1986	13.467	8.412	3.487	2.481	3.563	1.872	4.526	5.631	4.407	6.397	5.136	1.905	0.448	0.325	0.030	0153	176.2
1987	4.850	10.592	6.885	3.020	2.188	3.212	1.648	4.187	5.304	3.953	5.125	3.006	0.382	0.246	0.164	0.000	157.8
1988	4.540	3.814	8.670	5.976	2.670	1.968	2.869	1.505	3.943	4.754	3.280	3.010	0.587	0.205	0.123	0.000	134.0
1989	15.918	3.570	3.120	7.521	5.273	2.365	1.617	2.558	1.329	3.488	3.950	1.917	0.627	0.351	0.105	0.000	117.8
1990	17.526	12.521	2.922	2.711	6.667	4.768	2.145	1.501	2.425	1.289	2.922	2.387	0.409	0.392	0.188	0.000	112.9
1991	15.555	13.786	10.249	2.535	2.399	6.022	4.321	1.974	1.390	2.168	0.941	1.752	0.481	0.243	0.209	0.074	97.9
1992	11.586	12.235	11.282	8.907	2.246	2.167	5.490	4.011	1.868	1.223	1.759	0.535	0.331	0.239	0.112	0.078	90.0

TABLE 22. Fishing mortality rate of spiny dogfish during 1972-1992

Year	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1972	0.0000	0.0001	0.0005	0.0012	0.0015	0.0033	0.0096	0.0127	0.0251	0.0730	0.0922	0.2517	0.2536	0.4532	0.4626	0.1675
1973	0.0000	0.0001	0.0000	0.0002	0.0008	0.0006	0.0018	0.0036	0.0134	0.0321	0.0665	0.2126	0.3759	0.2224	0.1355	0.1715
1974	0.0000	0.0001	0.0003	0.0002	0.0009	0.0024	0.0042	0.0087	0.0208	0.0416	0.0506	0.2305	0.4089	0.3609	0.0564	0.1825
1975	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0037	0.0014	0.0054	0.0145	0.0368	0.2560	0.3333	0.4861	0.0779
1976	0.0000	0.0001	0.0002	0.0003	0.0008	0.0005	0.0036	0.0067	0.0116	0.0267	0.0587	0.2066	0.3151	0.4679	0.1384	0.1509
1972	0.0000	0.0001	0.0002	0.0003	0.0006	0.0019	0.0011	0.0079	0.0184	0.0320	0.0352	0.1458	0.2861	0.2186	0.2169	0.1242
1978	0.0000	0.0001	0.0001	0.0006	0.0005	0.0009	0.0036	0.0019	0.0142	0.0342	0.0365	0.1067	0.2550	0.2446	0.0523	0.1079
1975	0.0001	0.0011	0.0013	0.0026	0.0054	0.0092	0.0156	0.0412	0.0219	0.1554	0.2197	0.5247	0.8021	0.8057	0.3455	0.4277
1980	0.0001	0.0004	0.0002	0.0011	0.0016	0.0050	0.0083	0.0095	0.0421	0.0214	0.1039	0.3685	0.6111	0.5116	0.2781	0.2781
1981	0.0003	0.0005	0.0004	0.0007	0.0016	0.0028	0.0044	0.0102	0.0066	0.1652	0.0383	0.2864	0.4531	0.3642	0.1543	0.0000
1982	0.0004	0.0023	0.0031	0.0066	0.0079	0.0161	0.0087	0.0095	0.0211	0.0360	0.1139	0.1082	1.3598	0.4155	0.4155	0.4155
1983	0.0001	0.0036	0.0082	0.0065	0.0020	0.0203	0.0087	0.0120	0.0463	0.1261	0.0680	0.2457	0.0054	0.7096	0.0000	0.0000
1988	0.0001	0.0002	0.0002	0.0027	0.0014	0.0019	0.0014	0.0027	0.0113	0.0798	0.0687	0.1640	0.4119	0.0070	0.2375	0.0000
1985	0.0001	0.0013	0.0026	0.0074	0.0044	0.0071	0.0051	0.0134	0.0203	0.0240	0.0538	0.1154	0.1306	0.4567	0.0061	0.0807
1986	0.0001	0.0003	0.0040	0.0056	0.0038	0.0376	0.0080	0.0087	0.0188	0.0300	0.0457	0.0959	0.1806	0.0834	0.0880	0.0880
1981	0.0001	0.0002	0.0015	0.0032	0.0054	0.0230	0.0211	0.0099	0.0195	0.0266	0.0421	0.1232	0.2020	0.0923	0.0985	0.0000
1988	0.0002	0.0011	0.0023	0.0051	0.0214	0.1066	0.0445	0.0737	0.0327	0.0254	0.0472	0.0591	0.0940	0.0722	0.0566	0.0000
1986	0.0000	0.0004	0.0006	0.0005	0.0007	0.0071	0.0047	0.0036	0.0134	0.0171	0.0134	0.0338	0.0499	0.0228	0.0288	0.0000
1980	0.0000	0.0002	0.0026	0.0024	0.0017	0.0085	0.0130	0.0266	0.0221	0.0822	0.0212	0.0921	0.1000	0.0276	0.0200	0.0000
1981	0.0001	0.0005	0.0004	0.0005	0.0016	0.0026	0.0043	0.0051	0.0381	0.0492	0.0737	0.1567	0.2776	0.1757	0.0659	0.1404
1992	0.0001	0.0002	0.0015	0.0024	0.0032	0.0131	0.0087	0.0135	0.0214	0.0544	0.0634	0.1787	0.3441	0.3055	0.1689	0.1602

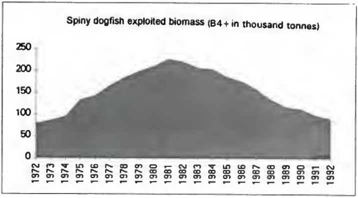


FIGURE 3. Spiny dogfish exploited biomass during 1972-1992

The intensification of the spiny dogfish fishery during the period 1979-1984, when the total catches rangad batwaan 6 419 and 12 254 thousend tonnas with a maan of 8 254 thousand tonnas, has contributed also to its stock decline.

Kirsonova (1993) showad thet tha TAC for spiny dogfish had to very from 5 to 6 thousand tonnas which corrasponds to U = 0.12 (this assessment in ralated to the former USSR coast). Tha atteinment of the leval U = 0.18 would laad to sharp decraase of stocks and eftar 10 years it would be cut by half, maintaing the trend towards further decline. For this reeson the spiny dogfish fishery statistical data for the real catches, especially eftar 1989 has to be availeble.

In **Tabla 23** ere shown both tha VPA and Kirsonove's results (1993).

TABLE 23. Spiny dogfish exploited biomess (thousand tonnas)

Year	Surveyed areas (x 10^{-3} km^2)	Exploited biomass (thousend tonnes)	VPA rasults (thousand tonnes)
1983	37.5	39.0	206.4
1984	34.8	44.0	203.6
1985	36.8	45.6	186.4
1986	30.0	47.8	176.2
1987	29.4	42.1	157.8
1988	24.6	46.7	134.0
1989	22.3	58.5	117.8
1990	21.5	58.7	112.9
1991	7.6	17.2	97.9
1992	25.6	62.9	90.0

Tha results from VPA relata to the whole Black Sea. From the figures during the pariod considered, the exploited fish stock in the former USSR waters made up on average 31.2% of the 2total stock in tha Black Saa. Bearing in mind the data of Kirsonova end Lushnikova (1990) for pray composition end quantities (by species) neaded ennually, tha VPA rasults for the stock size of all fish species (reflacting tha ralationships predator-prey) were used in the multilineer correlation analysis to consider the impect of the various biotic end abiotic factors. The results are presented in a separate saction whara thay ara discussed in detail.

STURGEONS, FAMILY *ACIPENCERIDAE*

Of the five sturgeon species inhabiting the Bleck See, tha most ebundent are: the Russian sturgeon, *Acipenser guldanstadti,* the sterred sturgaon, *Acipenser stellatus* end the greet sturgeon, *Huso huso*. The sturgeons spawn in the rivers Danube, Dniepar, Rioni end Kizil-Irmek, and form the separate populations or nationel stocks which composa the mejor componant of sturgeon stocks in the Black Sea. That is why the mein distribution and cetches of these fish species occur in the north-western part of the besin (Avertsev, 1960; Ambroz and Kiriljuk, 1979; Kolerov, 1986; Shlyakhov and Akselev, 1993). According to FAO Fishery Stetistics this yield comes from thrae areas: erea 05 - Bulgaria end Romenia; area 07 - former USSR end erae 37 - Bulgarie, Romenie end former USSR.

The sturgeon catches during the period 1963-1992 ere presented in **Table 24**.

Tha expert assessment of tha raal laval of sturgaon catches must teke into consideration illegal poacher catches in the former USSR, but similar corrections for Bulgarien end Romenian illegal cetches have not been included.

According to data of trewl surveys (Ambroz end Kiriljuk, 1969; Shlyekhov end Akselev, 1993) the stock sizes of sturgeons are given in **Table 25.**

Trewl surveys ere cerried out in February and March. During the period 1966-1981 the ereas investigated covered elmost ell the wintering ground of the Russian sturgaon, sterred sturgeon end tha young individuals of tha greet sturgeon. Matura specimens of the great sturgeon from the Denube population winter at depths 60-120 m along the entire western coest , including the continentel shelf off the southern Crimean waters. Therefore, the stock ebundance of the greet sturgeon is underestimeted end this eppreisel concerns meinly immeture fish. The eree investigeted efter 1981 is smeller end includes Kirkinitsky Bey end the western part of Tendre, covering almost completely the wintering grounds of the Russien sturgeon end elso the mein perts of the renge of the sterred sturgaon end the young fish of the greet sturgeon.

TABLE 24. Sturgeon catches in the north-western part of the Black Sea and the Danube

Year	According to FAO stetistics		Expert assessment of the ectual catches	
	Sturgeons	Russian sturgeon	Sturgeons	Russien sturgeon
1964	401.54	21.07	461.54	26.33
1965	457.61	28.32	502.61	35.41
1966	448.46	28.20	480.46	32.75
1967	342.90	72.00	367.90	90.00
1988	265.90	21.60	266.90	27.00
1969	298.20	28.80	313.20	36.00
1970	248.50	23.74	263.50	29.73
1971	230.80	30.24	244.80	37.80
1972	259.40	29.52	269.40	36.87
1973	281.40	24.48	295.40	30.60
1974	326.70	42.48	356.70	53.10
1975	242.60	39.70	256.60	49.48
1976	207.50	29.37	219.50	37.40
1977	238.30	69.98	278.30	97.90
1978	249.01	65.69	294.01	96.49
1979	229.28	44.08	250.26	83.74
1980	199.10	67.91	252.10	101.62
1981	171.30	60.91	214.30	87.62
1982	160.00	60.28	201.00	86.35
1983	155.00	60.28	196.00	86.35
1984	151.00	58.50	190.00	82.80
1985	119.00	34.67	183.00	73.81
1986	89.00	31.25	125.00	53.57
1987	98.00	47.88	153.00	79.65
1988	90.00	44.96	151.00	85.43
1989	61.00	28.25	106.00	60.62
1990	87.00	51.89	134.00	88.48
1991	32.00	23.58	87.00	67.73
1992	130.00	90.80	208.00	138.31
	42.00	24.04	323.00	194.42

TABLE 25. Sturgeon numbers (x 10^{-6} specimens - all species of ages 1-33) in the north-western part of the Black Sea (according to trawl surveys)

Year	Russian sturgeon	Starred sturgeon	Great sturgeon	Total N (x 10^{-6})	Total B (th.tonnes)
1966 - 1974	0.209	0.738	0.284	1.219	21.4
1975 - 1978	0.768	1.280	0.512	2.560	32.6
1981	0.616	1.792	0.392	2.800	34.7
1984	1.600/ 0.231*	1.100	0.250	2.950	15.5
1987	2.200/ 0.361*	1.040	0.280	3.520	20.3
1991	3.000/ 0.417*	1.830	0.140	4.970	34.7
1992	4.200/ 0.310*	1.100	0.060	5.360	30.6
1993	4.100/ 0.225*	1.980	0.130	6.210	27.1

* - the total abundence (1-33 years old) is indicated in the numeretor and those of exploited stock (14-33 years old) - in the denominetor.

Russian sturgeon from the **Danube stock** are caught in the Danube river and the western pert of the Black Sea. The spawning biomess includes only specimens older than 13 years, but the exploited biomass includes the species older than 10 years. Hence the exploited biomass includes also 10-12 years old fish. Some of these are immature but are subject to the commercial fishery, and therefore the biomess of the 10-12 yeer old fishes were edded to those of the mature fishes (spawning biomass). They do not include fish reised in hatchery in the Azov Sea.

A continuous set of data on the age composition of catches of the three species in question is available only for the Russian sturgeon. The stock essessment of this species, *Acipencer guldanstadti* wes carried out using the software package ANACO (Mesnil, 1989) which permits tuning of VPA by doing multiple of iterations to eliminate the bias when determining the initial value of fishing mortality coefficient (F_{st}). The natural mortality rate adopted is 0.05, and the mean weight by ages is obtained from the von Bertalanffy's equation (Domashenko end Akselev, 1993): $k = 0.059$; $t_o = -0.722$; $W_{oo} = 69.8$ kg. These essessments showed that the choice of F_{st} velue has almost no influence on the final results for the sturgeon's biomass from the Danube population, es the shere of the Dnieper population is insignificant. Nevertheless it comprises 20-24% of fish concentrations on the overwintering grounds (Shlyakhov, 1994) (**Tebles 26, 27** and **Figure 4**).

TABLE 26. Stock assessment (x 10^6 specimens and 10^{-3} tonnes) of Russian sturgeon from the Danube stock caught in Danube and Western Black Sea during 1963-1992

Year	10	11	12	13	14	15	16	17	18	19
1963	5.610	4.973	4.569	3.336	2.933	2.312	1.729	1.279	0.937	0.722
1964	6.137	5.313	4.567	4.084	2.976	2.542	1.882	1.547	1.058	0.790
1965	6.144	5.808	4.830	3.986	3.616	2.493	1.982	1.579	1.253	0.863
1966	8.038	5.815	5.318	4.263	3.542	3.124	1.968	1.691	1.298	1.061
1967	5.092	5.865	4.964	4.147	3.371	2.508	1.871	1.337	1.048	0.877
1968	7.666	4.820	5.218	4.410	3.687	2.894	2.053	1.619	1.103	0.890
1969	8.317	7.260	4.357	4.599	3.921	3.182	2.309	1.738	1.316	0.905
1970	7.630	5.982	6.717	3.843	4.148	3.445	2.641	2.018	1.488	1.134
1971	15.716	7.224	5.451	6.006	3.368	3.583	2.325	2.288	1.685	1.245
1972	11.662	14.918	6.839	4.812	5.432	2.851	2.954	1.992	1.946	1.455
1973	13.407	11.061	13.998	6.004	4.343	4.873	2.335	2.629	1.705	1.729
1974	22.158	12.707	10.186	12.778	5.307	3.823	3.981	1.905	2.170	1.409
1975	9.795	21.034	11.776	9.189	11.778	4.574	2.837	3,492	1.505	1.867
1976	12.293	9.285	19.772	10 823	8.455	10.845	3.891	2.476	3.089	1.282
1977	9.172	11.609	8.214	17.816	9.549	7.105	9.107	3.119	1.747	2.548
1978	12.289	8.642	10.434	6.836	16.212	8.158	5.570	8.088	2.356	1.277
1979	5.888	11.535	7.883	9.062	6.018	14.810	6.975	4.920	7.296	1.996
1980	15 259	5.518	10.438	6.279	7.846	4.804	12.836	6.030	4.052	6.535
1981	13.859	14.493	5.092	9.619	5.664	6.927	3.825	11.779	5.048	3.284
1982	17.517	13.168	13.728	4.582	8 743	4.461	5 287	3.005	10.563	4.401
1983	10.651	18.564	10.844	11.887	3.494	7.259	2.903	4.431	2.403	9.852
1984	9.501	9.909	14.094	7.981	9.962	2.445	6.005	2.390	3.978	2.217
1985	14.174	8.403	8.819	12.211	6.957	9.314	2.000	5.521	2.034	3.475
1986	28.758	12.802	7.614	8.028	10.902	6.238	8 764	1.712	5.140	1.797
1987	14.384	25.927	10.934	6.790	7.206	9.532	5.486	8.225	1.404	4.754
1988	21.975	13.486	23.967	9.916	6.277	8.647	8.678	4 992	7.706	1.245
1989	34.493	20.523	12.848	22.155	8.988	5.812	6.136	7.899	4.544	7.111
1990	36.652	32.279	19.010	11.791	20.230	7.951	5.316	5.587	7.038	4.050
1991	79.092	34.396	30.247	17.705	11.040	18.813	7.130	4 493	5.133	6.350
1992	96.578	74.149	31.792	27.051	15.915	9.706	16.328	5.697	4.028	4.643

Table 26 · continued

Year	20	21	22	23	24	25	26	27	28	29+
1963	0.580	0.492	0.411	0.365	0.304	0.264	0.133	0.184	0.142	0.411
1964	0.627	0.528	0.446	0.373	0.331	0.276	0.238	0.113	0.162	0.473
1965	0.669	0.561	0.471	0.401	0.331	0.298	0.244	0.208	0.089	0.502
1966	0.744	0.603	0.507	0.426	0.360	0.299	0.266	0.216	0.182	0.557
1967	0.799	0.817	0.499	0.422	0.346	0.298	0.239	0.208	0.161	0.501
1968	0.771	0.732	0.565	0.456	0.384	0.315	0.270	0.214	0.184	0.511
1969	0.763	0.698	0.667	0.513	0.411	0.347	0.281	0.238	0.186	0.636
1970	0.792	0.695	0.639	0.614	0.469	0.376	0.315	0.253	0.212	0.651
1971	0.990	0.715	0.629	0.583	0.558	0.427	0.338	0.281	0.222	0.740
1972	1.105	0.906	0.650	0.574	0.530	0.513	0.387	0.303	0.249	0.773
1973	1.312	1.021	0.837	0.599	0.527	0.489	0.472	0.353	0.273	0.834
1974	1.620	1.194	0.928	0.761	0.534	0.474	0.438	0.423	0.309	1.091
1975	1.226	1.396	1.095	0.849	0.690	0.479	0.421	0.387	0.373	0.955
1976	1.889	1.128	1.297	1.016	0.783	0.838	0.437	0.382	0.350	1.038
1977	0.991	1.492	0.992	1.168	0.902	0.696	0.558	0.367	0.315	0.994
1978	2.199	0.847	1.339	0.879	1.047	0.809	0.614	0.482	0.300	0.901
1979	1.065	2.028	0.752	1.217	0.779	0.965	0.738	0.553	0.428	1.333
1980	1.661	0.911	1.844	0.647	1.091	0.691	0.867	0.652	0.476	1.416
1981	5.896	1.430	0.742	1.655	0.518	0.963	0.583	0.751	0.546	1.653
1982	2.888	5.508	1.278	0.638	1.507	0.440	0.866	0.505	0.664	2.159
1983	4.060	2.703	5.203	1.186	0.578	1.411	0.396	0.801	0.458	1.602
1984	9.322	3.850	2.560	4.942	1.120	0.543	1.336	0.370	0.000	0.000
1985	1.857	8.760	3.485	2.198	4.553	0.950	0.458	1.183	0.331	0.000
1986	3.125	1.819	8.281	3.212	1.953	4.245	0.833	0.400	1.074	0.341
1987	1.547	2.760	1.369	7.818	2.934	1.695	3.937	0.712	0.340	2.344
1988	4.350	1.390	2.525	1.139	7.353	2.681	1.541	3.591	0.640	2.428
1989	1.181	3.981	1.249	2.310	0.935	6.921	2.452	1.400	3.274	2.475
1990	6.670	0.998	3.585	1.089	2.073	0.696	6.485	2.201	1.242	4.216
1991	3.650	6.241	0.867	3.240	0.962	1.882	0.522	6.096	1.998	8.031
1992	5.723	3.049	5.778	0.798	2.950	0.835	1.685	0.391	5.693	8.894

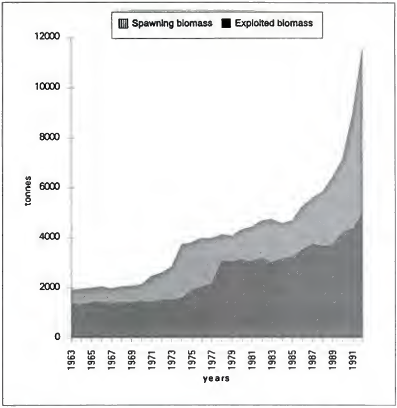


FIGURE 4. Spawning and exploited biomasses (in tonnes) of Russian sturgeon from the Danube stock during 1967-1992

TABLE 27. Fishing mortality rate (by ages) of the Russian sturgeon from the Danube stock during the period 1963-1992

Year	10	11	12	13	14	15	16	17	18	19
1963	0.004	0.035	0.062	0.064	0.093	0.156	0.095	0.142	0.123	0.091
1964	0.005	0.045	0.086	0.072	0.127	0.199	0.125	0.161	0.152	0.117
1965	0.005	0.038	0.075	0.068	0.096	0.186	0.109	0.146	0.116	0.099
1966	0.014	0.108	0.199	0.185	0.295	0.463	0.336	0.428	0.343	0.234
1967	0.005	0.032	0.068	0.068	0.103	0.150	0.095	0.142	0.114	0.079
1968	0.004	0.051	0.076	0.068	0.104	0.176	0.116	0.157	0.148	0.104
1969	0.004	0.028	0.075	0.053	0.079	0.130	0.085	0.119	0.099	0.084
1970	0.005	0.043	0.062	0.082	0.096	0.343	0.094	0.131	0.115	0.085
1971	0.002	0.035	0.085	0.051	0.117	0.143	0.104	0.112	0.096	0.069
1972	0.003	0.014	0.051	0.052	0.058	0.149	0.087	0.106	0.068	0.054
1973	0.004	0.032	0.041	0.083	0.131	0.152	0.153	0.142	0.141	0.079
1974	0.002	0.026	0.053	0.031	0.099	0.195	0.081	0.186	0.100	0.090
1975	0.003	0.012	0.034	0.033	0.033	0.112	0.086	0.073	0.110	0.050
1976	0.007	0.073	0.054	0.075	0.124	0.125	0.171	0.299	0.142	0.208
1977	0.010	0.057	0.134	0.044	0.107	0.193	0.069	0.228	0.263	0.098
1978	0.005	0.068	0.091	0.077	0.040	0.107	0.084	0.053	0.120	0.131
1979	0.015	0.059	0.152	0.094	0.175	0.093	0.096	0.144	0.060	0.133
1980	0.001	0.030	0.032	0.053	0.075	0.178	0.036	0.128	0.160	0.053
1981	0.001	0.004	0.055	0.045	0.189	0.220	0.191	0.059	0.087	0.079
1982	0.006	0.144	0.094	0.221	0.136	0.380	0.127	0.173	0.020	0.031
1983	0.022	0.111	0.257	0.127	0.307	0.140	0.145	0.058	0.031	0.005
1984	0.073	0.067	0.093	0.087	0.017	0.151	0.034	0.111	0.085	0.127
1985	0.068	0.049	0.044	0.063	0.059	0.011	0.105	0.022	0.074	0.056
1986	0.054	0.092	0.065	0.058	0.084	0.078	0.014	0.148	0.028	0.028
1987	0.014	0.029	0.048	0.028	0.031	0.044	0.044	0.015	0.070	0.070
1988	0.018	0.014	0.218	0.048	0.027	0.030	0.044	0.044	0.030	0.020
1989	0.016	0.027	0.020	0.041	0.083	0.039	0.044	0.065	0.065	0.014
1990	0.014	0.015	0.021	0.016	0.033	0.059	0.031	0.035	0.053	0.054
1991	0.015	0.029	0.062	0.057	0.079	0.081	0.174	0.147	0.050	0.054
1992	0.029	0.060	0.080	0.082	0.103	0.138	0.083	0.085	0.066	0.057

Teble 27 - continued

Year	20	21	22	23	24	25	26	27	28	29+
1963	0.047	0.047	0.046	0.049	0.048	0.056	0.115	0.081	0.067	0.067
1964	0.061	0.060	0.057	0.068	0.061	0.073	0.086	0.190	0.086	0.088
1985	0.054	0.052	0.051	0.058	0.054	0.057	0.070	0.082	0.072	0.072
1986	0.137	0.138	0.132	0.159	0.140	0.172	0.195	0.246	0.192	0.192
1987	0.037	0.037	0.040	0.045	0.042	0.049	0.082	0.071	0.059	0.059
1988	0.49	0.044	0.048	0.055	0.052	0.064	0.075	0.095	0.075	0.075
1969	0.043	0.037	0.033	0.041	0.038	0.045	0.056	0.067	0.057	0.057
1970	0.052	0.050	0.043	0.044	0.045	0.056	0.064	0.080	0.065	0.065
1971	0.039	0.045	0.042	0.045	0.036	0.047	0.059	0.072	0.057	0.057
1972	0.029	0.030	0.032	0.038	0.031	0.033	0.043	0.056	0.042	0.042
1973	0.044	0.046	0.045	0.064	0.056	0.061	0.060	0.082	0.070	0.070
1974	0.035	0.037	0.038	0.047	0.059	0.067	0.073	0.076	0.058	0.058
1975	0.032	0.024	0.025	0.031	0.029	0.041	0.047	0.052	0.045	0.045
1976	0074	0.079	0.054	0.070	0.068	0.084	0.125	0.114	0.105	0.105
1977	0.107	0.058	0.071	0.060	0.059	0.076	0.096	0.150	0.110	0.110
1978	0.031	0.069	0.045	0.070	0.032	0.041	0.055	0.070	0.078	0.078
1979	0.107	0.045	0.100	0.080	0.071	0.057	0.075	0.101	0.085	0.085
1980	0.100	0.155	0.058	0.178	0.074	0.120	0.094	0.127	0.119	0.119
1981	0.018	0.063	0.100	0.044	0.109	0.057	0.094	0.072	0.068	0.066
1982	0.016	0.007	0.024	0.049	0.016	0.055	0.028	0.048	0.025	0.025
1983	0.003	0.004	0.002	0.007	0.012	0.005	0.018	0.009	0.009	0.009
1984	0.012	0.049	0.102	0.032	0.115	0.120	0.071	0.060	0.000	0.000
1985	0.087	0.006	0.032	0.089	0.020	0.081	0.084	0.047	0.054	0.000
1988	0.074	0.118	0.008	0.041	0.091	0.025	0.108	0.114	0.062	0.082
1987	0.057	0.039	0.134	0.011	0.040	0.046	0.042	0.058	0.059	0.059
1988	0.057	0.057	0.039	0.147	0.011	0.039	0.046	0.043	0.056	0.056
1989	0.060	0.060	0.087	0.058	0.246	0.015	0.058	0.070	0.065	0.085
1990	0.089	0.089	0.048	0.073	0.047	0.238	0.012	0.047	0.056	0.056
1991	0.027	0.027	0.032	0.044	0.091	0.061	0.238	0.018	0.057	0.057
1992	0.056	0.056	0.058	0.085	0.055	0.062	0.066	0.065	0.058	0.058

When comparing the essessment of sturgeon abundance by trewl surveys with thet obtained using VPA, end teking into eccount the poecher's cetches, one cen see thet they ere very close, 310 x 10^3 and 259 x 10^3 (numbers), respectively - for fish over 14 yeers old. The difference is higher during the period 1981-1991, but the essessments heve the seme increasing trend . Probebly the difference in estimetes is due to the leck of precise determinetion of the poecher's cetches by Ukreine end Russie, which is not determined et ell in Bulgarie end Romania. As was steted the trewl surveys ere carried out in Februery-March; i.e. their estimates include fish from the Dnieper population (ebout 20-24% of the numbers on the wintering grounds). Irrespective of the differences in estimates pointed to, the results from VPA, comprising elso poecher's cetches, and confirm the conclusions of different euthors (Ambroz and Kiriljuk, 1969; Domashenko and Akselev, 1990) in eccounting for increese in sturgeon ebundance efter 1970. Moreover the assessments show unembiguously the great importance of correct fishery statistics data, since without an account of poacher's catches, the size of exploited and spawning biomasses ere considerebly underestimeted, perticulerly during the period 1991-1992. The underestimetes ere 26.6 to 41.6 times for the exploited stock, and 22.0 to 36.2 times for the spewning biomess.

According to Domeshenko end Akselev (1990) , the exploited stock includes fish older then 10-11 years, since meles attein sexuel meturity at ege 8-11 years, end females at age 13-15 years. Therefore, the spewning stock includes fish older then 13 years. Following the authors mentioned the exploited biomasses (B10+) in 1984-1987 were 5.0 end 8.6 thousend tonnes respectively, everaging 6.8 thousand tonnes. Our results for the same years ere 4.6 end 5.6 thousend tonnes, respectively, avereging 5.1 thousend tonnes i.e. 25% lower than those obtained by Domashenko and Akselev (1990). Concerning the yeer 1992, the differences are still smaller - 6.1 end 4.9 thousand tonnes, respectively (19.7%). The first value is based on Shlyakhov's deta, from trawl surveys carried in 1992.

The lower estimate (20-25%) of the sturgeon biomass from the Danube population (by VPA method) probably is due to the above mentioned fact, that trawl surveys are conducted through the winter months when the percentage of the fish from Dnieper population is only around 20-24%.

For the purpose of forecasting the future state of the sturgeon stock in the Black Sea it is necessary to consider in more detail its reproduction under natural and artificial conditions. After construction of Kahov's water-power system (a dam and network of canals) on the Dnieper, the length of the Russian sturgeon spawning ground (the starred sturgeon and the great sturgeon spawn mainly in the Danube) was reduced with about 75 km. The chief spawning grounds became inaccessible for mature fish and the Dnieper lost its previous importance as place for natural reproduction of sturgeons. Under these conditions the Danube remained the only big river where this fish species continues to spawn.

Basing on the data of the Odessa branch of YugNIRO which carries out permanent monitoring of the new year class abundance, it is concluded that the sturgeon's natural reproduction in the 1980s has been more successful than during the period 1966-1980 **(Table 28)**.

Comparing the density of the down stream dispersal of young sturgeon during the period 1966-1982, (which provides an index of the strength of the corresponding year classes) with the abundance of 10 - year - old fish during the period 1976 - 1992 (by VPA data) a common trend is apparent in their dynamics. Therefore there are good reasons to suppose that in the mid - 1990s the sturgeon stock will be recruited by strong year classes. In the beginning of the XXIth century, the species biomass will increase still more on account of additional reproduction of sturgeon at the Dnieper fish-farm. These optimistic forecasts would come true only on condition that fundamental measures against the poacher's catches in all Black Sea countries are undertaken however. In this respect the main responsibility falls on the corresponding institutions in Ukraine, as it is in its waters that the main nursery and wintering grounds of Russian sturgeon and starred sturgeon are situated. Another important problem are conditions provoking mass mortality of benthic organisms, since the sturgeon feeds on molluscs (42.6 to 94.6%), worms (0.0 to 29.6%) and crustaceans (0.0 to 33.2%). The percentages shown in brackets of the different prey items in the sturgeon diet vary with the size of the fish. The most affected from these groups of organisms are the molluscs and the crustaceans, which lead to a decline in the food level of these fish species. The starred sturgeon forages primarily on worms (from 31.6 to 78.8%), and crustaceans (ranging from 17.2 to 51.2% of its diet depending on fish size); the great sturgeon feeds on fish (4.8 to 100.0%) and crustaceans (0.0 to 95.2%), also depending on the fish size. Therefore the negative changes in any of the links in the ecosystem inevitably affect one way or another all living organisms inhabiting the relevant basin. This fact is verified by investigations carried out in 1992 (Shlyakhov's data - YugNIRO) showing that presently only 4 invertebrate species are found in the sturgeon diet - 2 polychaete , 1 crustacean and 1 mussel species, while previously 18 species of macrobenthos contributed to the sturgeon diet.

TABLE 28. Indices for natural (the Danube river) and artificiel (the Dnieper river, Dnieper sturgeon fish-ferm) reproduction of sturgeon in the north-western part of the Black Sea

Year	Natural reproduction (specimens/hectare)			Artificial reproduction ($x 10^{-6}$ specimens)
	Russian sturgeon	sterred sturgeon	great sturgeon	
1966	0.51	0.86	2.28	-
1967	4.28	5.94	2.04	-
1968	0.25	3.89	0.20	-
1969	1.18	4.59	0.37	-
1970	0.31	4.08	0.17	-
1971	0.05	0.15	0.05	-
1972	8.50	3.04	0.99	-
1973	1.28	2.96	0.41	-
1974	1.10	4.06	-	-
1975	2.10	4.33	-	-
1976	1.91	3.48	-	-
1977	5.51	9.36	2.63	-
1978	2.05	4.32	0.49	-
1979	1.20	0.60	5.10	-
1980	1.65	5.03	1.15	-
1981	3.69	9.84	1.64	-
1982	5.53	10.25	1.03	-
1984	12.85	2.38	8.57	-
1985	9.33	15.18	14.75	1.747
1986	7.14	6.72	13.86	2.288
1987	14.49	15.00	3.48	2.513
1988	15.49	16.01	14.49	1.958
1989	no data	no date	no deta	1.044
1990	no data	no deta	no data	1.884
1991	no data	no data	no data	1.839

BLACK SEA SHAD, *ALOSA KESSLERI PONTICA* EICHWALD

In the Bleck Sea only rapresentativas of tha genus *Alosa* exist; the commercially most importent being the shed (elso celled the Denube scomber) - ***Alosa kessleri pontica = Alosa pontica***, according to FAO Fishary Statistics. Tha texonomic position of the sheds is quite complicated but relying on tha FAO Yeerbook of Fishary stetistics we assign tha catchas of tha ramaining spacias or subspacias to *Alosa* spp.

The Black Sea shad is an anodromous fish undertaking spawning migrations in rivars, meinly in tha Danuba. Tha main pert of the stock winters off tha Turkish coast, and in tha eerly spring migretes elong the Bulgerien end Romanien coasts towards Danuba rivar. Tha fish enters tha river dalta during the sacond helf of March when the weter temparature is 4-6°C (Sardjuk, 1979; Kolarov, 1986).

The fishery for shed is cerriad out in tha saa (with trap-nats), es wall es in the rivar, end this is why its catches ara assigned to two araas - area 05 (Bulgaria, Romania and formar USSR) and araa 37 (Bulgaria, Romania, Turkay and former USSR). Ukreinien cetches heve alweys been reelised mainly in the Danube, and to a considarably lassar degraa in tha rivar Dnestre (eree 07). During the pariod 1987-1992, Turkish catches exceeded 1 000 tonnes, end in the FAO Fishery Statistics, these catches are ralatad to *Alosa* spp. Tha graatar amount of Turkish catchas ara mada on tha aastern Anatolian coast, and for this reason it is unlikely that these cetches ere from the Denube populetion of the Bleck See shed. This is the reeson elso why the pert of Romanian catches raletad to *Alosa* spp. according to FAO, are not included. Tha Romanian stetistic show that during the period 1970-1992, the following amounts of clupaoid fish are caught: **(Tabla 29)**

TABLE 29. Romanien shed (genus *Alosa*) catchas during 1970 - 1992

Year	Alosa pont.	Alosa caspie	Year	Alosa pont.	Alosa cespia	Yaar	Alosa pont.	Alosa caspie
1970	211	77	1978	247	137	1986	-	1137
1971	375	136	1979	471	-	1987	-	1357
1972	311	95	1980	392	-	1988	-	388
1973	726	188	1981	251	332	1989	8	229
1974	878	219	1982	232	494	1990	-	150
1975	2158	540	1983	230	669	1991	-	255
1976	534	451	1984	236	501	1992	13	85
1977	640	161	1985	140	348			

In **Tabla 30** tha total Black Sea shad catches (*A.pontica*) in araa 05 and 37 ara presented.

TABLE 30. Total Black Sea shad catches (tonnas) during 1970-1992

Yaar	A.pontica	Year	A.pontica	Year	A.pontica
1970	1473	1978	1698	1986	985
1971	1526	1979	2920	1987	709
1972	1291	1980	1475	1988	1695
1973	2269	1981	1284	1989	699
1974	4491	1982	2520	1990	947
1975	6043	1983	2127	1991	414
1976	3845	1984	2030	1992	1007
1977	3018	1985	1791		

Stock assessments of Black Sea shad by VPA ara available from the monograph of Ivanov and Bevarton (1985) and also from Kolarov's doctorata thasis (1986).

Our own assessment concarns tha pariod 1970-1992 and is basad on tha following data:

- tha ege composition for the period 1970 - 1982 follows Kolarov's doctorate thesis, end for the period 1983-1992 from summarised data of Shlyakhov and Maxim
- tha natural mortality coafficiants by aga group is aftar Ivanov and Bevarton (1985)
- the valuas of total mortelity coefficiant ara computad on tha base of aga composition using regressions
- the mean velua of M was subtracted from the obtained veluas of Z in ordar to get the initial values of F_{st}
- the weight by age classes are summarised using Bulgarian, Romanian and Ukrainian data

The assessments ere cerried out by means of the software package ANACO with tuning of F valuas. Tha rasults from tha analysis ara prasantad in **Tablas 31** and **32, Figuras 5** and **Figura 6.**

TABLE 31. Stock assessment (x 10^6 specimens) of *A. pontica* in the Black Sea during 1970-1992

Year	1	2	3	4	5	6	7
1970	40.297	11.477	13.028	5.244	4.717	0.389	0.000
1971	56.520	28.397	8.084	8.808	2.027	1.775	0.023
1972	67.136	39.829	20.003	4.634	1.836	0.427	0.138
1973	46.647	47.309	27.991	10.715	2.189	0.667	0.015
1974	35.557	32.852	33.113	16.051	4.376	0.508	0.035
1975	24.593	25.057	22.924	14.309	6.410	1.570	0.000
1976	28.985	17.329	17.464	8.697	2.390	1.437	0.053
1977	31.099	20.423	11.951	6.834	1.173	0.347	0.053
1978	21.652	21.911	13.827	3.154	1.172	0.296	0.027
1979	38.127	15.245	14.808	5.583	1.106	0.458	0.013
1980	39.764	26.866	10.293	3.452	0.742	0.316	0.022
1981	26.788	28.021	18.691	4.533	1.930	0.043	0.000
1982	19.848	18.873	19.522	9.618	1.738	0.420	0.000
1983	22.775	13.946	12.972	7.893	3.685	0.519	0.000
1984	13.416	16.018	9.658	5.339	2.473	1.490	0.000
1985	17.693	9.426	11.118	4.689	0.841	0.431	0.000
1986	13.325	12.442	6.154	5.004	0.577	0.140	0.030
1987	12.101	9.375	8.709	3.021	1.810	0.084	0.000
1988	8.650	8.517	6.537	5.282	0.777	0.772	0.000
1989	12.748	6.072	5.903	3.075	0.326	0.058	0.048
1990	4.355	8.975	4.242	3.669	0.723	0.061	0.000
1991	18.523	3.056	6.225	2.704	0.500	0.050	0.000
1992	7.738	13.047	2.110	4.261	0.970	0.105	0.000
1993		5.440	9.088	1.184	0.769	0.140	0.003

TABLE 32. Fishing mortality rate of *A. pontica* during 1970-1992

Year	F_{st}	F_{3-6}	Year	F_{st}	F_{3-6}	Year	F_{st}	F_{3-6}
1970	0.537	0.363	1978	0.380	0.561	1986	1.055	0.539
1971	1.075	0.585	1979	1.076	1.209	1987	0.530	0.343
1972	0.494	0.307	1980	2.001	0.653	1988	1.664	1.291
1973	0.884	0.327	1981	0.530	0.367	1989	0.667	0.480
1974	0.423	0.499	1982	0.352	0.570	1990	1.303	0.919
1975	1.145	0.913	1983	0.401	0.574	1991	0.359	0.261
1976	1.508	0.959	1984	1.225	0.847	1992	0.294	0.426

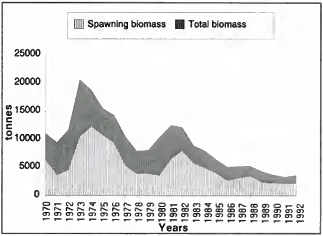


FIGURE 5. Total and spawning biomass of *A. pontica* (tonnes)

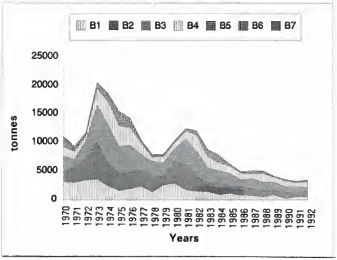


FIGURE 6. Exploited biomass (by age groups) of Black Sea shad (*A. pontica*)

Tebla 32 shows tha astimates of F_{st} and also the meen weight valuas of F_{3-6} following iteration procedures. In Figure 5 ere shown the fluctuations in the totel (81 +) and in the spewning (83 +) biomasses of the 8lack See shed during the period 1970-1992. Figure 6 presents the results from VPA for the biomess, by age groups. The essessments shown have e similer trend to Kolerov's estimetions (Kolerov, 1986), but they differ in ebsolute values our assessments being considerably higher. The principal reason for these differences is that Kolarov uses the meen velue of the coefficient M and does not make tune the VPA by the corresponding iteretions for F_{st} velues. Our estimate is very close to thet obteined by Ivanov end 8everton (1985) who use considerably higher values for M for the oldest age groups in order to explain the sharp decrease of abundance in the catches. According to the euthors mentioned, the total shed biomess in 1968 and 1974 was 2 957 end 20 007 tonnes, respectively. Our estimatas show thet the totel biomass in 1973 and 1974 wes, respectively, 20 664.9 end 18 759.3 tonnes, i.e. very close to the corresponding velue for 1974 stated by Ivenov end Beverton (1985).

The stock-recruitment relationship of 8lack Sea shad was derived on the basis of VPAs results for recruitment (R-1 year old fish) and spawning biomass (8r) during the previous yeer. The date usad are presented in table 32b.

TA8LE 32b. Date points used in Figure 7

Yeers	R	Br	Yeers	R	Br
1971	56.520	7968.5	1982	19.848	10666.3
1972	67.136	6387.6	1983	22.775	10601.5
1973	46.647	8207.5	1984	13.416	7393.8
1974	35.557	16973.4	1985	17.693	6964.0
1975	24.593	16264.0	1986	13.325	5142.7
1976	28.995	13816.5	1987	12.101	4131.5
1977	31.099	12253.3	1988	8.650	4336.4
1978	21.652	8065.4	1989	12.748	4583.7
1979	38.127	6519.7	1990	4.355	3238.6
1980	39.764	5389.1	1991	18.523	3360.6
1981	26.788	7365.5	1992	7.738	2640.6

Figure 7 shows tha ralationship between the biomess of fish older than 2 yaars (according to Kolerov, 1986 over 95% of 2 yeer old fish have reached sexual maturity), and the abundence of 1 yeer old fish during the following year. It is seen from the figure thet the goodness of fit (r) for Ricker's equetion ($R = e.E.e^{-bE}$) is 0.3355, i.e. the impact of the environment is much more significent than the size of the perent stock. Tha parameters of Rickar's equation found ere es follows: a = 6.1841; b = -0.00005697; R_{mex} = 39933.4 x 10^{-6} specimens of 1 year old fish; B_{opt} = 17553.1 tonnes spawning biomess.

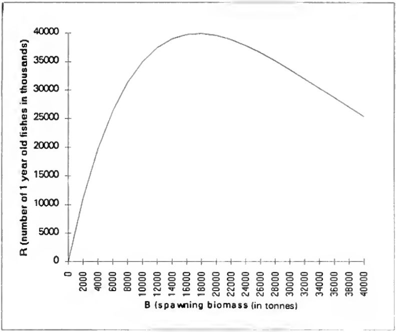


FIGURE 7. Stock-recruitment relationships of *Alosa pontica*

Ivanov and Kolarov (1979) established the existence of inverse interrelationships between catch size and solar activity (measured from the number of sun spots - the Wolf's number). In order to explain this phenomenon, these authors suppose that in years of transition from maximum to minimum solar activity, more favourable conditions for shad ere creeted. The same euthors, as well as Ivanov and Beverton (1985), point out that the historical data for Wolf's number not only confirms this cyclic recurrence, but may even precede an increase of catches for the next cycle. This conclusion was arrived at on the basis of existing data for the period 1927-1979. Other authors (Vledimirov, 1953; Moroz and Krotov, 1969) draw attention to the fact that when the water level of the Denube river is high during spring and summer, it coincides with eppeerence of a strong year class and after some years leads to increased shed catches.

BLACK SEA ANCHOVY, *ENGRAULIS ENCRASICOLUS PONTICUS* ALEKSANDROV

Recently tha Black Saa anchovy has baan considerad one of tha populations of the European anchovy, *Engraulis encrasicolus* Linnaanaus, by some authors (Lindbarg, 1980; Tshashchin, 1985; Dobrovolov, 1988; Dobrovolov and Mikhailov, 1990), whila others considar it a distinct subspacias (Fage, 1911; Aleksandrov, 1927; Pusanov, 1936; Svatovidov, 1948; Rass, 1987; Prodanov *et al.*, 1993).

Commarcially and acologically, the Black Saa anchovy is tha fish spacias of primary importance in the basin. Being most abundant, it has traditionally supported the largest commercial fishary in tha Black Sea. The anchovies low trophic position gives it a significant role as a componant of the anergy flow to higher levals, thus considerably affacting the acosystem as a whola. On this account, there has been extensive interest in this fish and appreciable effort was davotad to studying its biology, ecology and exploitation paramaters.

Recent research advances work concarn the discovery of hybridisation batwaan the Black Saa and Azov anchovy populations (Tchashchin, 1985; Mikhailov and Dobrovolov, 1990). Moreovar, migrations of Azov and/or hybrid types wara established through electrophoretic and morphometric studias along tha Bulgarian coast, primarily during autumn and wintar (Mikhailov and Dobrovolov, 1991).

The anchovy is known to mature at 1 year of age but sinca 1987 young-of-tha-yaar anchovias (some months after hatching) wara detactad maturing and spawning in tha north-wastarn part of tha basin (Mikhailov, 1991; Lisovenko *et al.*, 1993).

Tha co-axistanca of two populations (Black Saa and Azov stocks) in tha Black Saa and tha high fluctuations in anchovy stock biomass, anforcad tha applying of naw and mora raliabla methods of surveying and assassmant of anchovy rasources. Since 1978 ragular echo-acoustic and (sinca 1980), acho-intagrator surveys hava commancad off tha Caucasian and Crimaan coasts during the wintering period (November-April) carried by YugNIRO (Ukraina). Thay aimad at investigating the distribution, and obtaining separate estimates of tha two stocks, thus providing the possibility of rationalising their fisharies (Artyomov and Tchashchin, 1982; Tchashchin, 1990). Sinca 1984 joint (tha formar USSR and Bulgaria) acho-intagrator surveys hava baan carriad out off the Bulgarian coast, which showed relatively good anchovy concantrations evan at tha beginning of the autumn migration. For instance, the biomass early in Septamber 1984 was estimated at 32 thousand tonnes.

Sinca 1987 regular ichthyoplankton survays hava baan conducted by YugNIRO. Both Bulgaria and Romania have joined consecutively in 1989 and 1990. Their final goal was to assass tha spawning biomass by Parker's "agg production mathod" (Parker, 1980) (Arkhipov *et al.*, 1992; Mikhailov *et al.*, in press) successfully used for other anchovy stocks (northern anchovy, Peruvian anchovy, atc.). Tha rasults obtainad show a drastic decline of spawning biomass aftar 1988: 1988 - 235 000; 1989 - 32 000, 1990 - 48 000, and 1991 - 92 000 tonnes in tha Black Saa.

Tha rasaarch performed revealed the negative natural and anthropogenic impacts dua to the Mnemiopsis outburst and anchovy ovar-fishing, in particular); simultanaously acting on tha anchovy stock size and population structure.

Tabla 33 shows the anchovy catches by countrias during fishing seasons 1967/1968 - 1993/1994

TABLE 33. Black Sea anchovy catches (tonnes) during fishing seasons 1967/1968 - 1993/1994

Fishing seasons	Bulgaria	Romania	former USSR	Turkey	Total
1967/1968	210	2072	42450	43065	87797
1968/1969	104	901	50050	36422	87477
1969/1970	68	713	58100	53801	112682
1970/1971	137	1921	56050	66738	124846
1971/1972	83	1508	52300	76058	129949
1972/1973	313	3466	65100	85061	159087
1973/1974	86	642	80800	77509	159037
1974/1975	8	207	87200	64509	151924
1975/1976	59	2266	148000	70326	220651
1976/1977	134	3183	125000	56742	185059
1977/1978	38	1113	118000	84686	203837
1978/1979	272	3951	71000	76391	151614
1979/1980	187	3146	170000	264325	457658
1980/1981	121	4932	120000	274710	399763
1981/1982	107	2941	126000	267389	396437
1982/1983	890	8329	130000	267888	407107
1983/1984	150	1743	145000	309729	456622
1984/1985	229	6066	70000	181019	257314
1985/1986	98	2553	100000	302770	405421
1986/1987	23	827	100000	350087	450937
1987/1988	11	394	130000	338402	468807
1988/1989	106	2953	70000	115237	188296
1989/1990	0	38	65000	130975	196008
1990/1991	1	1	2000	37049	39051
1991/1992	82	122	25000	72295	97499
1992/1993	7	279	4000	69450	73736
1993/1994	0	346	0	77468	77814

It is clear that both Romanian and Bulgarian catches (in the western part of the Black Sea, only) represent insignificant proportions of the total catches; on average 1.03%. The Romanian catches are taken in April-December but mainly in May-August. They were distributed by months, as follows (in %):

Months	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
%	0.87	17.B5	25.70	33.52	14.87	6.69	0.47	0.02	0.01	100

The Bulgerian monthly catches were, respectively:

Months	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
%	4.64	36.43	12.26	15.61	6.53	2.78	10.71	4.82	6.22	100

The Turkish and former USSR yields (in the eastern part of the Black See) heve alweys been dominant. The fishery is cerried out in October - April, but mostly from Decamber - March (96.03%). The former USSR catchas distributed by months are the following (in %):

Months	X	XI	XII	I	II	III	IV	Totel
%	0.25	2.80	26.71	32.46	24.48	12.98	0.32	100.00

The monthly catch distribution for Turkey is similar. However, during tha last two fishing seasons a significant shift in the cetch distribution by querters has been observed (catches in %):

Quarters	X-XII	I-III	IV-VI	VII-IX	Total
1992/1993	66.50	33.50	0.00	+	100.00
1993/1994	85.88	14.12	0.00	0.00	100.00

From the figures given it is apparent that during the two fishing seasons mentioned the catches were obtained, as eerly es October-December, averaged 76.19%, while those in Januery-March sharply decreesed, averaging 23.81%. Such variations in catches ere normal for all regions undar consideration. Various causes may be responsible for this, beginning with the environmental conditions and ending with the stock size in different yeers. For instance, during the last few years (1990-1992) when the enchovy total and spewning biomasses dropped dramatically, its catchas in the western part of the Black See were negligible. For the occurrence of dense concentrations, emount of fet daposited in the fish and the sea water temperature, are of great importance . The data from research surveys showed that 1+ and 2+ year old fishes begin to form schools at water temperetures 14-16°C when the fat content reaches 12-17%. For 0+ yeer old fishes, the indices ere 10.5-13°C and not less than 13% fat, respectivaly. All this inevitably affects the period of migration of the perticular age groups, es well es the migration of the different cohorts of 0+ year old fishes.

Figure 8 shows anchovy stock size during the 1967/1968 - 1993/1994 fishing seesons (three estimetes were cerried out). Two of them were performed with software package ANACO (Mesnil, 1989) end the third by the modified equation of Baranov (Shlyakhov *et al.*, 1990). The former two differ between them primarily by the epproach to defining the initiel F_{st} velues: (Tha initial F value for oldest ege groups). In the first estimete the values of F_{st} have been determined by regressions on the basis of the age composition of the catches. After that, iteretion procedures were used to eliminate possible errors when computing F_{st}. The background to this method is tha assumption thet fishing mortality rates heve to be epproximately equal for ell fully availeble ege groups in the exploitad stock. In the sacond epproach the F_{st} values ware calculeted on the basis of the regrassion between the estimated initiel F_{st} velues and Turkish fishing effort data. Hence, a correction of the F_{st} values was made (**Table 34**).

The results obtained from VPA show that the final estimates after 9-10 iterations (performed until the difference between the mean F values for ages 2+ and 3+, become less than 0.01 for all fishing seasons) ware almost aqual during the period 1978/1979 - 1990/1991. For this reason, two estimates only are presented in **Figure 8**, one from the VPA estimates, the other according to Barenov's equetion es modified by Shlyakhov, Chashchin and Korkosh (1990).

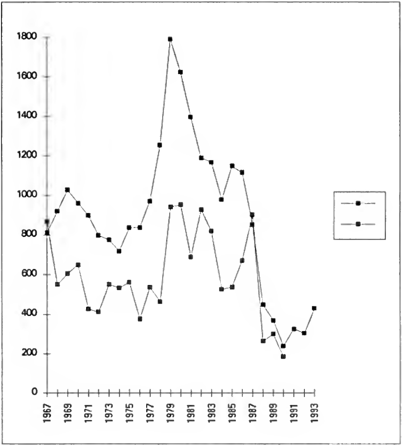


FIGURE 8. Anchovy exploited biomass (in thousand tonnes) during the period 1967 - 1993.
Upper line: results from VPA
Lower line: results from Baranov's modified method

TABLE 34. Values for anchovy fishing mortality rate during the period 1967/1968 - 1993/1994; F_{st} - initial value for the oldest age group. The givan values are estimatad by tha regression curvas of catch age composition; $F_{st}*$ - F_{st} is specified by tha ragrassion curve of Turkish fishing effort data; F_{1-4} and $F_{1-4}*$ wera obtained by corresponding values of F_{st} and $F_{st}*$, respectively

Fishing seasons	F_{st}	F_{1-4}	$F_{st}*$	$F_{1-4}*$	$F_{0-4}**$	U
1967/68	0.3516	0.2795			0.16	0.105
1968/69	0.3300	0.2308			0.26	0.159
1969/70	0.3790	0.2217			0.31	0.186
1970/71	0.4374	0.2987			0.32	0.192
1971/72	0.2346	0.3433			0.56	0.304
1972/73	0.3778	0.4286			0.73	0.374
1973/74	0.4607	0.4845			0.52	0.289
1974/75	0.2940	0.4992			0.51	0.285
1975/76	0.5265	0.4976			0.79	0.394
1976/77	0.6190	0.6133			1.10	0.491
1977/78	0.5506	0.3386			0.75	0.380
1978/79	0.5541	0.2677	0.3518	0.2682	0.61	0.326
1979/80	0.5887	0.5565	0.5282	0.5569	1.08	0.486
1980/81	0.6186	0.4863	0.5055	0.4866	0.86	0.420
1981/82	0.4879	0.5589	0.5618	0.5591	1.44	0.575
1982/83	0.4388	0.5292	0.5453	0.5295	0.92	0.438
1983/84	0.5136	0.6705	0.6039	0.6709	1.40	0.556
1984/85	0.5152	0.5428	0.5034	0.5429	1.09	0.489
1985/86	0.5949	0.7767	0.7031	0.7769	2.78	0.754
1986/87	0.7888	0.9492	0.7733	0.9496	2.00	0.671
1987/88	0.8865	1.6147	0.9465	1.6149	1.20	0.520
1988/89	0.7452	0.8827	0.8546	0.8829	2.34	0.713
1989/90	0.4325	0.9310	0.8573	0.9912	1.89	0.655
1990/91	0.3145	0.3920	0.4424	0.4832	0.86	0.212
1991/92	0.4520	0.4730				
1992/93	0.3559	0.4576				
1993/94	0.3013	0.3795				

U=Y/B; Y - catch per fishing seeson; B - exploited biomass at the beginning of the corresponding fishing saason

The mean values for $F_{0-4}**$ (calculeted from Shlyakhov *et al.*, 1990) for ages 0+ to 4+ are baliavad to be fairly accurata because the equation $Y = B. F/Z (1 - e^{-Z})$ is not equal to tha equetion $C = N. F/Z (1\text{-}e^{-Z})$ - Prodanov and Kolarov (1983).

Tha values of F_{1-4} ara means for ages 1+ to 4+ from age composition celculated by Taylor's method.

Tebla 34 shows thet using this VPA approach, the initiel velues of F_{st} heve no serious effect on the finel essessment, with the exception of the last fishing seeson, date for comparison of the two approachas are evailable (1990/1991). The differencas obtained during the mentioned letar years (e mejor problem of VPA) were due to the fect thet the yeer classes hed not completed their life spen, especielly 0+ and 1+ yaer old fishes. All this reduces the eccurecy of the forecests for the stock size in the next fishing season. In this respect, estimetions suggesting that tha total enchovy biomess increesed during the 1993/1994 saeson, contein the highest possibility for error. Thet is why the catches pradicted to ba tekan in the fishing seeson 1994/1995 will be of extreme importence for the accuracy of the appraisels mede for the lest two fishing seesons. This problem compliceted still more if one considers that the cetches do not elways reflect exectly the stock size due to conditions determining the occurrance of densa concentretions susceptible to fishing. Therefore, there does not elways exist e coincidence between Turkish and the former USSR deta for cetchas par fishing vessel during 1981/1982 - 1988/1989. Similar comparison of the catches is et present impossible in view of the speciel situetion in Georgie, es e result of which nowedeys no foreign fishing cen be carried out along its coast. This would incidentally fevour recovery of the anchovy biomass. On the other hend, the Mnemiopsis biomass increesed egein (Teble 13) during the summer of 1994 (preliminery Ukreinien deta).

This is the mein reeson why we suppose thet the expected trend towards increesing enchovy biomass may change once more, since the fish hes e short lifetime end the entry of even one weak yeer cless would leed to e declina of tha exploited stock. The positive effect diminished fishing effort, espacially in unfavourable environmentel conditions, is of greet importence (Prodenov, 1990) and this may be decisive for the anchovy biomass recovery.

This has elreedy bean observed in the See of Azov where after cessation of the enchovy fishery for e few yeers, its stock increesed considerebly in spite of the high Mnemiopsis biomass.

The third estimate was accomplished with tha modified Baranov's aquation. This method is besed on anchovy spewning biomass dete obteined eerly in May by trewl surveys, the catches, end the values of Z. Out of these three parameters, the highest errors come from the biased essessment of the spewning biomass. Estimatas by their common trend with this method, era akin to those obtained by two previous approaches using VPA. Howevar, they differ significantly in the absolute figures obtained. For exemple, eccording to VPA, tha total biomass (B_{0+}) in November 1979 reached 1 791,5 thousand tonnes end then dropped to 237.3 thousend tonnes et the beginning of November 1990. During the seme yeers, the essessments by Berenov's equetion were 942.4 end 184.3 thousend tonnes, respectively.

Figure 9 shows the results from VPA conducted by the usuel approech, i.e. the computed values for F_{st} were not subject to edditional iterations, except for those inherent to the method. These astimetes do not differ essentially from thosa by tha sama mathod, but eccompanied by edditionel iterations for reconciling the F values for fully recruited age groups. Thus, during tha two years considered (1979 and 1990) the exploited enchovy biomess had been 1 765.0 end 262.4 thousend tonnes, respectively. The essessment showing en increase of exploited biomess (389.1 thousand tonnes) et the beginning of November 1993 then is akin to values obtained by the above-mentioned approeches to VPA, respectively. The seme concerns the predicted spewning biomass (B1+) at the beginning of the fishing season 1994/1995; notebly 215.8 thousand tonnes. The lowest estimate comes from the approach that corrects the initial values of F_{st} by means of the regression between them end the Turkish fishing effort dete. During the two years considered, the totel biomass wes es follows: 1979 - 1 676.6 thousand tonnes and 1990 -194.0 thousend tonnas.

Each estimate wes mede using the following weights (g) in November:

Age	0+	1+	2+	3+	4+
Weight	4.7	11.9	16.3	19.0	21.3

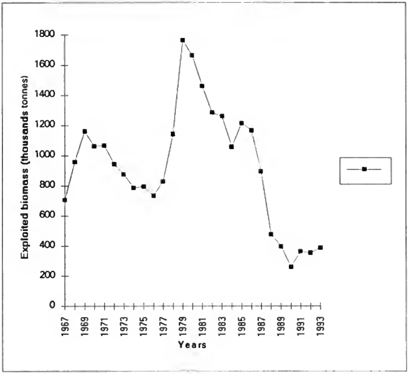


FIGURE 9. Exploited anchovy biomass during 1967 - 1993 (the values for F_{st} are not corrected by additional iterations)

The deta differ from those reported by Ivanov end Beverton (1985) primarily in tha first two age groups. Latar on, Ivanov and Mikhailov (1990) spacified the growth rate of tha youngest aga class. The authors assumed that the larvaa hatchad (probably aerly in June), ettained a weight of 5.5 g at 150 days of aga (i.e. early in November). Following tha sama approach the hatched larvae early in July end August would reach the same waight of 5.5 g in early Decambar and January, respectively. Howaver, the environmental conditions in the lest two months ara much less favourable for anchovy growth since it is a warm-watar species. Tharafore the lata cohorts of 0+ year old fishes probably remain in Anatolian waters, while the early cohorts of the sama year cless mainly hibernate off the Georgian coast. This assumption is consistent with Turkish data for the distribution of age 0+ weights by months:

Recent data largely stemming from recent data on Turkish catches, suggest that the recovery of anchovy populations hes been more pronounced. The spawning and exploited biomassas et the beginning of May 1993, and in the 1993 fishing seas on (November) is calculated to have reached 297 and 637 thousand tonnes respectively, as opposed to earlier calculations which suggested 170 and 340 thousand tonnes for these same quantities.

Months	Age 0+ - weights (g)
November	5.37
December	4.69
January	3.32
February	4.04
March	4.47
Average	4.40

It is seen from **Tables 37 and 38** that trends in anchovy stock size are akin to those determined by the above and differ only in absolute values. According to VPA conducted by season, the spawning and exploited anchovy stocks have ranged from 137.5 (1990) to 768.1 (1979) thousand tonnes and from 271 (1990) to 1 427.4 (1979) thousand tonnes (**Figures 10 and 11**). The steady decline in exploited biomass is associated with the poor environmental conditions in the Black Sea, and the outburst of the ctenophore *Mnemiopsis leidyi*, and the over-exploitation of the anchovy stock during 1987-1989. During the period in question the coefficient of exploitation ($U = Y/B_{0+}$) ranged between 0.422 and 0.567 with the corresponding F values 0.81 and 1.44, respectively.

TABLE 35. Number (x 10^{-9} specimens) of anchovy spawning (early May) and exploited stocks (early November) in the Black Sea

Year	V 0	XI 0+	V 1	XI 1+	V 2	XI 2+	V 3	XI 3+	V 4	XI 4+
1967	113.00	75.10	23.20	15.30	7.02	4.63	2.53	1.68	0.77	0.51
1968	90.50	60.00	45.30	30.00	6.96	4.53	2.08	1.37	0.80	0.52
1969	96.50	64.00	35.50	23.50	16.80	11.10	2.06	1.36	0.60	0.40
1970	103.00	68.60	35.40	23.50	12.10	8.02	6.22	4.12	0.58	0.38
1971	81.40	54.00	41.50	27.50	11.50	7.54	3.28	2.13	2.13	1.41
1977	73.50	48.70	31.20	29.70	14.90	9.55	3.00	1.96	0.82	0.54
1973	95.30	63.20	26.60	17.60	8.87	5.83	4.47	2.95	0.63	0.41
1974	85.10	56.50	28.30	18.80	6.99	4.62	2.42	1.58	1.58	1.04
1975	122.00	81.20	29.70	19.00	8.03	5.32	1.58	1.10	0.45	0.31
1976	95.50	63.40	33.30	22.00	8.23	5.37	1.76	1.13	0.38	0.24
1977	132.00	87.30	32.30	21.40	8.60	5.63	1.72	1.12	0.38	0.25
1978	169.00	112.00	43.20	26.60	9.78	6.35	2.55	1.68	0.45	0.29
1979	217.00	144.00	68.70	45.50	14.40	9.48	3.33	2.19	0.93	0.61
1980	176.00	116.00	63.60	41.80	16.00	10.50	4.36	2.87	0.80	0.53
1981	141.00	93.40	56.60	37.40	15.80	10.40	4.50	2.94	1.31	0.86
1982	137.00	90.70	45.50	30.10	13.40	8.87	3.82	2.51	1.14	0.75
1983	152.00	101.00	44.90	29.70	12.00	7.77	3.31	2.14	0.84	0.52
1984	128.00	84.70	40.20	26.60	10.10	6.52	2.89	1.85	0.68	0.45
1985	161.00	107.00	48.30	32.90	11.10	7.31	2.42	1.90	0.73	0.51
1986	152.00	104.00	53.70	35.60	10.80	7.11	2.10	1.37	0.42	0.27
1987	93.50	62.00	49.70	32.90	11.00	7.29	1.63	1.08	0.37	0.24
1988	60.10	39.90	21.30	13.80	6.49	4.29	1.71	1.13	0.19	0.13
1989	63.10	41.80	15.00	9.95	4.52	3.00	1.54	1.02	0.45	0.30
1990	40.20	26.70	12.80	8.51	3.00	1.99	0.94	0.82	0.00	0.00
1991	50.70	33.60	15.20	10.10	4.52	3.03	0.99	0.66	0.00	0.00
1992	39.50	26.20	14.90	9.86	4.66	3.08	1.46	0.97	0.00	0.00
1993	54.60	36.20	12.90	8.57	4.55	3.02	1.41	0.94	0.45	0.30
1994			18.30		4.22		1.49		0.45	

TABLE 36. Values of anchovy fishing mortality coefficient (by age) in the spawning and exploited stock during the period 1963-1993 ; V - May ; XI - November

Year	V 0	XI 0+	V 1	XI 1+	V 2	XI 2+	V 3	XI 3+	V 4	XI 4+
1967	0.0006	0.0961	0.0054	0.3771	0.0069	0.3901	0.0004	0.3363	0.0006	0.3362
1968	0.0005	0.1156	0.0011	0.1694	0.0211	0.3794	0.0098	0.4157	0.0064	0.3253
1969	0.0005	0.1828	0.0004	0.2529	0.0034	0.1710	0.0022	0.4405	0.0011	0.4656
1970	0.0001	0.0935	0.0012	0.3038	0.0044	0.4837	0.0034	0.2476	0.0069	0.4413
1971	0.0001	0.1384	0.0007	0.2318	0.0110	0.5123	0.0200	0.5405	0.0061	0.1876
1972	0.0016	0.1954	0.0017	0.4361	0.0002	0.3501	0.0168	0.7260	0.0179	0.3946
1973	0.0007	0.3938	0.0009	0.5139	0.0110	0.4703	0.0053	0.2146	0.0077	0.4573
1974	0.0001	0.2687	0.0010	0.4387	0.0042	0.6132	0.0104	0.8188	0.0051	0.2254
1975	0.0006	0.4825	0.0002	0.4276	0.0017	0.6958	0.0047	0.6509	0.0063	0.5245
1976	0.0001	0.2643	0.0027	0.5292	0.0166	0.7275	0.0331	0.6654	0.0280	0.6396
1977	0.0000	0.2942	0.0003	0.3741	0.0133	0.3823	0.0231	0.4941	0.0086	0.5584
1978	0.0000	0.0797	0.0019	0.2765	0.0216	0.2369	0.0104	0.1813	0.0244	0.4975
1975	0.0001	0.4088	0.0020	0.6376	0.0070	0.3667	0.0062	0.5923	0.0129	0.5959
1980	0.0013	0.3115	0.0087	0.5605	0.0137	0.4316	0.0070	0.3753	0.0072	0.6029
1981	0.0008	0.3083	0.0040	0.6155	0.0141	0.5880	0.0155	0.5429	0.0094	0.4895
1982	0.0002	0.2931	0.0054	0.5056	0.0089	0.5719	0.0125	0.6834	0.0018	0.4341
1983	0.0004	0.5127	0.0028	0.6694	0.0269	0.5804	0.0254	0.7304	0.0512	0.5083
1984	0.0005	0.1516	0.0037	0.4612	0.0276	0.5789	0.0340	0.4635	0.0104	0.5037
1989	0.0002	0.2782	0.0028	0.6735	0.0082	0.8391	0.0063	0.9328	0.0026	0.5914
1986	0.0001	0.3314	0.0014	0.7642	0.0093	1.0632	0.0177	0.9066	0.0320	0.7860
1987	0.0003	0.6610	0.0026	1.2244	0.0016	1.0388	0.0059	1.3239	0.0038	0.8837
1988	0.0001	0.5677	0.0235	0.7036	0.0023	0.6131	0.0010	0.5134	0.0038	0.7313
1989	0.0001	0.7721	0.0002	0.7894	0.0002	0.7532	0.0001	0.4823	0.0016	0.4823
1990	0.0000	0.1549	0.0000	0.2124	0.0000	0.2905	0.0000	0.3144	0.0000	0.0000
1991	0.0001	0.4063	0.0002	0.3600	0.0002	0.3210	0.0001	0.4517	0.0000	0.0000
1982	[illegible]	0.2971	0.0003	0.3637	0.0002	0.3741	0.0001	0.3507	0.0000	0.0000
1993	0.0006	0.2711	0.0015	0.2996	0.0014	0.2996	0.0001	0.2996	0.0000	0.2996

TABLE 37. Anchovy spawning biomass (B_{1+} in thousand tonnes) in early May during the period 1967-1993

Year	1	2	3	4	Total
1967	158.5	83.1	39.2	14.0	294.8
1968	309.4	82.4	32.2	14.6	438.8
1969	242.5	198.9	31.9	10.9	484.2
1970	241.8	143.3	96.3	10.6	492.0
1871	383.4	138.2	50.8	38.8	509.2
1972	213.1	171.7	48.4	14.9	446.1
1973	181.7	105.0	69.2	11.5	367.4
1974	193.3	82.8	37.5	28.8	342.4
1975	196.0	95.1	25.7	8.4	325.2
1976	227.4	87.4	27.2	8.9	358.9
1977	220.6	101.8	26.6	6.9	355.9
1978	295.1	115.8	39.5	8.3	458.7
1979	469.2	170.5	51.5	16.9	708.1
1980	434.4	189.4	67.5	14.6	705.9
1981	388.8	187.1	69.7	23.8	667.2
1982	310.8	158.7	59.1	20.7	549.3
1983	306.7	142.1	51.2	15.3	515.3
1984	274.8	119.6	44.7	12.4	451.3
1985	329.9	131.4	37.5	13.3	512.1
1986	366.8	127.9	32.5	7.7	534.9
1987	339.5	130.2	25.2	6.7	501.8
1988	145.5	76.8	28.5	3.5	252.3
1989	102.5	53.5	23.8	8.3	188.1
1990	87.4	35.5	14.6	0.0	137.5
1991	103.8	54.1	15.3	0.0	173.2
1992	101.8	55.2	22.6	0.0	197.6
1993	88.1	53.9	21.8	8.3	172.1
1994	125.0	50.0	23.1	8.4	206.5

TABLE 38. Anchovy exploited biomass (B_{0+} in thousand tonnes) in early November during the period 1967-1993

Year	0+	1+	2+	3+	4+	B0+	U
1967	353.0	182.1	75.5	31.9	10.3	653.4	0.1344
1968	282.0	357.0	73.8	26.0	11.1	749.9	0.1167
1969	300.8	279.7	180.9	25.8	8.5	795.7	0.1416
1970	322.4	279.7	130.7	78.3	8.1	819.2	0.1523
1971	253.8	327.3	122.9	40.5	30.0	774.5	0.1677
1972	228.9	246.3	155.7	37.2	11.5	679.6	0.2341
1973	297.0	209.4	95.0	56.1	8.7	666.2	0.2387
1974	265.6	223.7	75.3	30.2	22.2	617.0	0.2462
1975	381.6	226.1	86.7	20.9	6.6	721.9	0.3058
1976	298.0	261.8	87.5	21.5	5.1	673.9	0.2747
1977	410.3	254.7	91.8	21.3	5.3	783.4	0.2601
1978	526.4	339.2	103.5	31.9	6.2	1007.2	0.1505
1979	676.8	541.5	154.5	41.6	13.0	1427.4	0.3207
1980	545.2	497.4	171.1	54.9	11.3	1279.5	0.3125
1981	439.0	445.1	169.5	55.9	18.3	1127.8	0.3515
1982	426.3	358.2	143.8	47.7	16.0	992.0	0.4104
1983	474.7	353.4	126.7	40.7	11.1	1006.6	0.4536
1984	398.1	316.5	106.3	35.2	9.6	865.7	0.2972
1985	502.9	380.8	119.2	30.4	10.9	1044.2	0.3882
1986	488.8	423.6	115.9	26.0	5.8	1060.1	0.4253
1987	291.4	391.5	118.8	20.5	5.1	827.3	0.5667
1988	187.5	164.2	69.9	21.5	2.8	445.9	0.4223
1989	196.5	118.4	48.9	19.4	6.4	389.6	0.5031
1990	125.5	101.3	32.4	11.8	0.0	271.0	0.1443
1991	157.9	120.2	49.4	12.5	0.0	340.0	0.2868
1992	123.1	117.3	50.4	18.4	0.0	309.2	0.2384
1993	170.1	102.0	49.2	17.9	6.4	339.2	0.2294

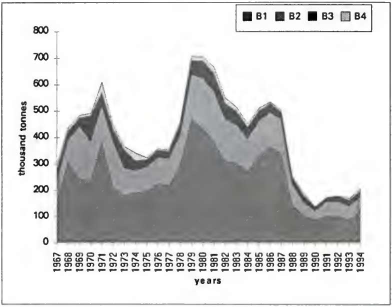


FIGURE 10. Spawning biomass of the Black Sea anchovy in early May 1967-1993

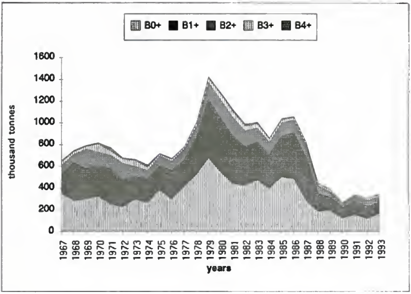


FIGURE 11. Exploited biomass of the Black Sea anchovy at the beginning of the fishing season (November) in the period 1967-1993.

Anchovy stock size assessments agree with those performed by Johanesson and Loose (1973); Ivanov and Beverton (1985); Ivanov and Mikhailov (1990). The first estimate was obtained from trawl (hydroacustic survey) in March 26-31, 1976, off the Turkish coast. From this the anchovy biomass during this year was 990.0 thousand tonnes. On the basis of these data and the fact that the assessment was releted only to the wintering stock off the Anatolian coast, Ivanov and Beverton (1985) estimated the stock in the whole Black See at eround 1 500 thousand tonnes. Ivenov and Mikhailov (1990) gave an everege estimete of the exploited anchovy biomass of 1 000 thousand tonnes assuming thet in some years it has peaked at 1 300 thousand tonnes.

BLACK SEA SPRAT, *SPRATTUS SPRATTUS PHALAERICUS* RISSO

During the lest 20 yeers, the sprat hes been most ebundant and commercially importent fish spacies in the western Black Sea. It is also of graat importanca for the acosystem since it represents an important link between the plankton community end its predators. Thus its population level exerts top-down control on the lower components of the foodweb, and bottom-up control on the apicel components of the ecosystem.

In the specific environmental conditions of the Black Sea tha spret ettains a smeller size and has a shorter life span than the same types in the Atlantic end Mediterrenean. In view of a large stock tha species is of primary importance for energy trensfer through the trophic web: the fish ensures the trensition from plankton to predators. Among predetors of spret there ere invertebretes, fish end mammals. Dolphins, spiny dogfish, meckerel, whiting, turbot, etc. ell feed on adult sprats. The eerly lifa stages era components of the diet of horse mackerel and predatory megaplankton. This wide spectrum of predators suggests a high natural mortality thet determines the short life span and high individual growth rate.

Climetic changa is the other factor conditioning such e growth rate: some authors (Stoyenov, 1965) believed that low winter temperatures end strong off-shore winds are one of the major ceuses for weak year clesses.

The Black Sea sprat possesses great adaptive capacity, such as a short life span, hance high stock turnover, high growth rate, early sexual maturity, batch spawning end protracted spewning period. These biologicel feetures ere specific response to environmantal conditions, and they compensate for the high rata of elimination the population is subjected to.

In **Table 39** are presented spret catches from 1951-1993. From this teble, it is seen thet Russian lendings after 1978 rapresented 95% of the total sprat catches in the Black Sea; mostly coming rom the north-western part of the basin.

TABLE 39. Sprat landings in the Black Sea (thousand tonnes)

Year	Bulga-ria	Roma nia	former USSR	Total	Year	Bulga-ria	Roma-nia	former USSR	Total
1951	1.6	0.6	1.7	3.8	1972	3.0	2.3	0.8	6.1
1952	1.2	1.3	0.7	3.1	1973	3.4	2.2	0.9	6.5
1953	0.6	1.4	0.9	2.9	1974	4.5	1.2	0.5	6.2
1954	0.6	2.0	4.4	7.0	1975	5.6	0.7	0.8	7.1
1955	0.5	0.7	0.5	1.7	1976	7.2	1.6	1.6	10.4
1956	1.9	0.9	4.2	6.9	1977	8.7	1.5	6.7	16.9
1957	2.3	0.9	3.3	6.5	1978	10.6	1.5	22.8	34.9
1958	2.3	1.3	2.2	5.8	1979	13.5	2.3	57.9	73.7
1959	1.8	1.4	2.6	5.9	1980	16.6	1.0	66.9	84.4
1960	1.9	1.4	1.3	4.5	1981	18.9	2.3	75.1	96.3
1961	1.2	2.8	0.3	4.2	1982	16.5	3.0	56.3	75.8
1962	1.4	2.1	1.8	5.3	1983	12.0	3.4	25.5	40.9
1963	1.2	2.2	1.0	4.4	1984	13.9	4.5	24.1	42.5
1964	0.9	3.0	3.7	7.6	1985	15.6	6.8	28.8	51.2
1965	1.1	4.4	4.0	9.5	1986	11.5	9.0	43.1	63.6
1966	0.2	0.5	2.0	2.7	1987	11.0	9.5	59.1	79.6
1967	0.7	0.7	1.3	2.7	1988	6.2	6.5	54.2	66.9
1968	1.1	1.7	1.7	4.6	1989	7.4	8.9	88.9	105.2
1969	1.1	0.9	0.5	2.6	1990	2.7	3.2	48.0	53.9
1970	1.4	1.3	0.3	3.1	1991	1.9	7.3	15.7	24.9
1971	2.5	1.3	0.8	4.7	1992	2.9	2.1	14.6	19.5
					1993	2.4	2.4	9.0*	13.8

The growth enalyses were performed on the besis of summerised mean length et eges in Bulgerien cetches for cohorts of seesons 1977-1990, es well as on dete from Ukreinien trawl surveys carried out in Mey-June 1980-1990 (**Teble** 40). Growth wes simuleted by meens of the von Bertalanffy's function (VBGF), and the software VONBER hes been used for this purpose (Sperre, 1987).

TABLE 40. Length et ege dete (TL in *cm*) end VBGF peremeters from YugNIRO TS

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	6.65	6.76	6.54	6.21	6.43	6.98	6.65	6.87	7.64	6.76
1	8.74	9.07	9.29	9.40	9.51	8.63	8.85	9.18	9.18	8.52
2	10.17	10.28	10.06	10.17	10.06	10.28	10.61	10.17	10.28	10.06
3	10.61	10.73	10.61	10.50	10.39	10.95	11.61	10.61	10.95	10.95
4	11.94	11.83	11.94	11.72	11.83	11.94	12.38	11.94	11.94	11.83
L_{∞}	13.46	12.48	12.24	11.50	11.59	14.11	14.19	12.69	14.27	14.04
k	0.339	0.464	0.516	0.77	0.7	0.287	0.36	0.417	0.244	0.292
phi'	1.788	1.859	1.889	2.008	1.974	1.757	1.860	1.827	1.697	1.760

For the purpose of enelysis of annual dynamics the growth performance index was applied (Pauly and Munro, 1984):

(1) $phi' = \log_{10}k + 2 \times \log_{10}Loo$

For determining the thaoratical limits of variation of the totel end neturel mortality coefficient different theoretical and empirical equations described in Veffer (1988) and Sparre (1989) Black Sea paremeters derived from the litereture were used.

Assessments of mortelity coefficients, the optimel level of exploitetion, stock-recruitment reletionships end the level of totel, exploited end spawning biomasses, ere presented in the pepers of Stoyanov (1966); Ivanov (1983, 1990,1994); Ivanov end Beverton (1985); Efimov *et al.* (1985); Prodanov (1990); Prodenov and Deskelov (1992), Daskelov (1993), Deskelov and Prodanov (1995).

Table 41 shows the results of YugNIRO ichthyoplankton trawl end ecoustic surveys for April-June.

TABLE 41. YugNIRO research survey assessments: offspring ($N * 10^{-9}$) from ichthyoplankton surveys (IS) in April and perent stock (tonnes $* 10^{-3}$) from trewl end ecoustic surveys in Mey-June

Year	1967	1968	1969	1970	1971	1972	1973	1974	1975
offspring	30.9	51.3	22.0	74.2	6.1	163.1	31.5	32.0	52.0
parent stock	145.0	187.0	210.0	152.0	218.0	134.0	157.0	370.0	490.0
Year	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**
offspring	28.9	30.5	60.1	48.6	51.3	68.7	368.3	86.9	276.6
parent stock	400.0	240.0	960.8	1071.6	1609.6	740.0	427.2	288.5	492.8
Year	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
offspring	215.3	22.1	92.4	23.9	38.1	440.9	93.4	193.1	269.4
parent stock	215.3	22.1	92.4	23.9	38.1	440.9	93.4	193.1	

Age composition data of combined catches (1953-1966) and from trawl surveys (1967-1992) were explored by the linearized catch curve (Sparre, 1989):

(2) $\ln Ct = g - Z^*t$

between the obtained values of Z by years and standardised effort (f) for two periods: 1953-1973 with primarily a near shore fishery (with passive gears) and high stocks of pelagic predators, and 1976-1992 with a trawl fishery and reduced predatory impact. Regressions were performed in order to find the mean annual natural mortality coefficient:

(3) $Z = M + q^*E$

The fishing effort for the first period was estimated on the basis of data on trapnet numbers per year concerning Bulgaria, Romania and the former USSR, and for the second period from trawl catch data (**Table 42**). Fishing effort was standardised by dividing the total catch by the sum of weighted by corresponding catch relative CPUE by gears (details of the method in Sparre, 1989).

A number of researchers, including the results of MSVPA, showed that natural mortality coefficient of recruits is different and often sizeably higher for the parent stock. In order to obtain approximate estimates of M for age 0+ (July-December) the relationship derived by Petersen and Wroblewski (1984) and the theoretical individual weight (w) of 0+ year old fish in the beginning of October: 3.17 g (Ivanov, 1983) were used.

(4) $M(w) = 6.1^*10\text{-}8(s\text{-}1)^*w\text{-}0.25$

To obtain estimates of fishing mortality and number at age during VPA was used. Data are presented in **Table 43.**

TABLE 42. Total catch at age (N x 10^{-6}) and stock weight at aga (g) in the beginning of the year matrices used in VPA

Year	Catch	at age	N x 10^{6}				Wt	at	age,	g		
age	0+	1	2	3	4	5	0+	1	2	3	4	5
1951	0.0	1620.3	8.3	23.1	0.0	0.0	1.9	2.6	3.9	5.3	8.2	10.7
1952	0.0	268.8	492.6	0.0	0.0	0.0	1.9	2.5	4.1	5.9	7.9	10.7
1953	0.0	525.4	218.2	44.1	0.0	0.0	1.9	2.7	3.5	6.0	8.6	10.7
1954	0.0	1615.8	655.7	70.3	0.0	0.0	1.9	2.3	3.6	5.5	8.5	10.7
1955	0.0	512.2	93.7	2.4	0.0	0.0	1.9	2.3	3.7	5.1	8.4	10.7
1956	202.4	2145.2	281.5	0.0	0.0	0.0	1.9	2.0	3.5	5.8	8.2	10.7
1957	227.7	2668.2	113.7	7.0	0.0	0.0	1.9	2.2	3.4	5.1	8.3	10.7
1958	210.7	1613.7	316.3	6.1	0.0	0.0	1.9	2.7	3.7	5.5	7.9	10.7
1959	90.5	431.8	843.8	76.7	0.0	0.0	1.9	2.5	4.4	5.9	8.1	10.7
1960	0.0	891.0	295.7	162.5	0.7	0.0	1.9	3.0	4.3	5.8	8.4	10.7
1961	631.7	491.2	371.4	35.8	1.8	0.0	1.9	2.9	4.4	6.0	8.1	10.7
1962	277.0	576.3	589.2	91.2	5.8	0.0	1.9	2.6	4.5	6.0	8.2	10.7
1963	0.0	751.1	337.5	96.8	5.1	0.0	1.9	2.7	4.2	5.8	8.6	10.7
1964	52.3	1728.1	505.8	62.8	9.8	0.0	1.9	2.3	4.1	6.3	8.2	10.7
1965	0.0	2900.8	372.0	40.7	8.0	0.0	1.9	2.2	4.0	6.2	8.7	10.7
1966	0.0	840.0	122.0	22.2	1.8	0.0	1.9	2.9	4.1	6.2	8.8	10.7
1967	97.1	340.5	142.8	19.7	0.7	0.0	1.9	2.3	4.4	6.9	8.6	10.7
1968	75.5	680.3	269.5	44.0	5.7	0.0	1.9	2.5	4.4	6.4	9.0	10.7
1969	24.5	298.5	171.9	26.4	1.7	0.0	1.9	2.7	4.6	6.8	8.8	10.7
1970	34.8	571.2	87.6	13.2	1.6	0.0	1.9	2.8	4.8	6.9	8.7	10.7
1971	33.5	472.6	367.1	19.7	1.4	0.0	1.9	3.0	5.1	7.5	8.8	10.7
1972	60.3	417.1	495.6	87.9	2.0	0.0	1.9	2.6	5.5	7.8	9.3	10.7
1973	60.7	577.3	429.6	126.6	3.5	0.0	1.9	2.8	4.9	7.3	9.6	10.7
1974	30.6	1150.4	176.2	21.2	1.3	0.0	1.9	3.0	5.1	7.1	8.8	10.7
1975	0.4	303.4	783.0	93.7	33.9	3.0	2.6	4.2	6.6	7.6	8.6	10.8
1976	0.8	332.2	723.1	329.6	86.0	5.2	2.7	4.3	6.6	7.7	8.5	10.4
1977	45.9	555.5	715.8	551.6	253.3	4.6	2.5	4.4	6.6	7.6	8.6	10.3
1978	222.5	1771.6	1282.9	939.5	234.7	34.9	2.6	4.1	6.6	7.7	8.6	10.0
1979	422.4	4309.7	3432.6	1543.4	356.0	13.8	2.4	4.2	6.2	7.4	8.2	10.1
1980	68.9	8430.0	4041.0	755.3	409.0	99.5	2.4	3.8	5.6	7.4	8.3	9.9
1981	165.6	7894.6	4161.6	946.6	285.0	191.3	2.2	3.9	6.2	7.5	9.2	10.8
1982	64.6	8014.0	2553.4	335.8	114.8	74.7	2.3	4.4	7.5	8.8	9.6	10.7
1983	30.9	5464	798.4	380.6	164.1	57.8	2.0	4.2	7.0	8.2	9.2	10.3
1984	35.8	6913.3	913.6	194.7	86.9	9.1	1.7	4.1	6.8	7.7	8.5	10.2
1985	58.9	7153.5	1868.2	240.3	3'1.0	0.0	1.8	3.5	7.1	8.5	9.4	11.0
1986	60.7	9082.3	2535.9	1041.6	185.2	0.0	1.9	2.9	5.7	7.8	9.5	10.5
1987	80.6	6516.3	5467.5	1146.2	92.4	0.0	2.0	3.2	6.2	7.5	8.9	10.7
1988	7.1	9177.4	1432.8	885.5	262.7	0.0	1.9	3.6	6.0	8.1	9.4	10.6
1989	119.9	9299.8	5240.2	2162.3	896.6	0.0	2.6	3.6	5.6	7.7	8.8	10.5
1990	538.0	4401.1	2599.6	1952.2	302.3	0.0	1.5	3.0	5.8	6.9	9.1	10.9
1991	162.1	2650.7	449.5	34.7	18.3	0.0	1.5	2.1	4.4	7.1	9.4	10.8
1992	30.6	1614.8	1276.6	318.8	58.1	4.4	1.7	2.1	4.5	6.8	8.6	10.8
1993	559.3	1417.2	1058.3	203.3	5.7	0.0	1.7	2.5	3.6	6.0	7.7	10.8

The matrix of catches was obtained by summing up the corresponding catches of Bulgaria, Romania and the former USSR.

The basic problem in VPA is tha determining of the fishing mortality coefficient for the oldest ege group. Different modificetions of the method solve this problem in different ways. In the present work the softwere VPA Lowestoft 3.1 peckege (Perley end Fletmen, 1994) wes epplied.

The separable VPA (Popa and Shepherd, 1982) suggests that fishing mortality at age for every year (Fa,y) is a rasult of the influence of a characteristic annual effect (Fo,y) on the one hend, end ege effect on the other hend, expressed by a specific selectivity pettern by ages (Sa). Tha sepereble VPA does not require data for tuning.

(5) $Fe,y = Fo,y*Se$

The second approach is the VPA with *ad hoc* tuning of fishing mortality using additionel information for fishing mortality (Pope end Shepherd, 1985). This method estimates the fishing mortality for the last year (Fat,y) as proportional to the meen of some proceeding ages (avFai,y) at permanent exploitation pattern.

(6) $Fat,y = avFai,y*So; \quad 0 \quad So \quad 1$

The tuning of fishing mortelity for the lest yeer wes performed by Laurec and Shepherd's method (1983) which assumes permanent catchability at ages (qa) and log-normal distribution of deviation from the mean value. The fishing mortality by ages and fleets wes obtainad as:

(7) $Fa,y,f_1 = Fa,y * Ca,y,f_1/Ca,y,tot$

where: f_1 is index of fleet; C - catch in number.

The catch ability by fleets was respectively:

(8) $qe,y,f_1 = Fe,y,f_1/Ey,f_1$

where Fa,y,f_1 is fishing mortality for a given fleet; Ey,f_1 is fishing effort for a given fleet .

The relationships between growth end biomass level was investigatad by Fox's function (Fox, 1974):

(9) $q = e*B^{-b}$

The peremeters wera estimated by tha Solvar function in the EXCEL spreedsheet. Tha reletionship between yield end fishing mortelity coefficient wes investigeted in the seme menner:

(10) $Y = a*F*axp(-b*F)$

The stock-recruitment relationship wes esteblished eccording to the generelized non-linear model of Shepherd (1982):

(11) $R = e*B/[1 + (B/b)^c]$

In our fishery analysis, four data files of catches end efforts were used (**Teble 43**). Date from ichthyoplankton surveys (IS) were used for tuning the recruitment abundance for the last year, by constructing regressions between survey data and that obtained through VPA astimatas. For this purpose the softwere RCT3 (Shepherd end Darby, in press) was used.

TABLE 43. Tuning data by fleet: effort in fishing hours (x 10^{-3} and catch-at-age (TS and IS in $N*10^{-9}$)

Year	Bulgaria, Bourgas, $N*10^{-6}$						USSR Small vessels, $N*10^{-6}$					
	Effort	0+	1	2	3	4	effort	0+	1	2	3	72.
1978	21.2	5.4	376.3	576.7	292.0	43.0	21.2	8.9	1374.3	726.5	163.5	35.
1979	23.8	49.7	524.7	856.5	340.3	36.9	35.5	112.9	2834.6	1064.	167.4	195
1980	25.8	12.7	1165.2	807.1	140.2	24.8	38.2	31.7	4104.4	1686.	271.5	136
1981	24.1	21.9	519.3	1241.	283.1	41.3	48.1	80.0	4445.0	1477.	331.9	51.
1982	25.4	14.2	1364.7	671.3	125.3	10.5	48.0	25.1	3276.9	851.5	81.7	86.
1983	24.7	10.4	1490.0	290.8	92.4	17.3	44.1	12.1	2158.2	258.7	159.2	52.
1984	27.4	17.6	2507.3	268.3	39.4	3.7	43.3	12.9	2422.4	354.4	93.7	13.
1985	20.1	8.1	1969.5	682.3	57.2	5.2	44.5	28.5	3746.4	687.3	44.9	116
1986	21.2	2.7	1349.1	617.2	105.4	13.6	48.8	30.6	4890.3	941.7	519.5	50.
1987	15.5	18.1	748.5	1071.	85.2	7.9	59.9	51.3	4938.3	2910.	513.2	226
1988	14.1	0.9	868.1	286.5	102.2	5.7	68.2	5.1	6835.2	738.9	596.2	781
1989	13.0	20.6	1076.3	570.9	62.2	3.6	80.4	85.9	6380.1	3669.	1777.	277
1990	7.8	28.6	299.9	106.1	29.5	3.3	76.7	448.9	3464.2	2206.	1774.	15.
1991	7.2	20.2	315.6	31.9	5.3	2.6	21.0	128.4	2073.1	384.6	25.0	39.
1992	7.0	7.5	352.3	141.9	11.0	1.3	14.5	19.4	989.6	819.5	221.9	1.2
1993	4.2	16.3	104.5	96.7	24.7	0.5		515.7	1011.6	430.7	61.4	

Table 43 - continued

Year	USSR, Large vessels, Nos*10^{6}						YugNIRO TS				IS
	Effort	0+	1	2	3	4	1	2	3	4	0
1978	2.1	1.6	240.9	127.3	28.6	12.7	68.3	36.1	8.1	3.6	60.1
1979	13.2	88.2	2215.4	831.9	130.9	28.0	96.0	36.1	5.7	1.2	48.6
1980	13.5	21.8	2829.6	1162.3	187.2	134.9	167.7	68.9	11.1	8.0	51.3
1981	18.3	46.5	2582.8	858.4	192.9	79.4	70.1	23.3	5.2	2.2	68.7
1982	17.3	20.3	2655.2	689.9	66.2	41.8	45.3	11.8	1.1	0.7	368.3
1983	11.8	5.2	933.6	111.9	68.9	37.2	35.1	4.2	2.6	1.4	86.9
1984	4.8	2.4	451.8	66.1	17.5	9.8	62.1	9.1	2.4	1.4	276.6
1985	1.9	2.6	340.6	62.5	4.1	1.2	50.6	9.3	0.6	0.2	215.3
1986	9.1	11.7	1877.2	361.5	199.4	44.9	260.5	50.2	27.7	6.2	22.1
1987	4.8	7.2	696.9	410.2	72.3	7.1	111.2	65.6	11.6	1.1	92.4
1988	3.8	0.5	740.8	80.1	64.6	24.6	34.6	3.7	3.0	1.1	23.9
1989	8.4	11.8	873.0	502.1	243.3	107.0	30.8	17.7	8.6	3.8	38.1
1990	2.7	20.7	159.5	101.6	81.7	12.8	16.1	10.2	8.2	1.3	440.9
1991	0.5	5.1	82.4	15.3	1.0	0.6	32.5	6.0	0.4	0.2	93.4
1992	0.5	1.1	57.4	47.5	12.9	2.3	30.8	25.5	6.9	1.2	193.1
1993		24.3	47.7	20.3	2.9	0.5	88.0	37.4	5.3	0.1	269.4

The third method used was: Extended Survivors Analysis (XSA). Improved analysis of survival (Shepherd, 1992) combines the approaches of tuning and use in *ad hoc* techniques and in RCT3.

Applying the relationship between CPUE and biomass by ages and fleets, XSA tunes the abundance for the last year (Na,yt), assuming constant catchability in time for fully recruited age groups, and year-class strength dependent catchability for the non recruited ones. XSA has a comparatively complex algorithm, described in Darby and Flatman (1994), permitting different ways of weighing a temporal series and "shrinkage" towards mean Fa,yt or Na,yt. XSA was applied for the first time for the Black Sea sprat on the basis of data for tuning, represented in **Table 43**.

To determine the major characteristics of sprat stock dynamics, such as growth rate, mortality rate and biomass, the age structure of catches was analysed. The obtained series of estimates were investigated, searching for some simple relationships. The results obtained (**Table 44**) show that sprat growth parameters undergo considerable variation between years.

The period 1977-1993 was characterized by a decrease in mean size and an increase in growth rate. Growth was smoothed by averaged data for 4 sub periods (Fig. 12). The highest growth rate was observed in the middle of the period while in the beginning and at the end, the curves show a slower growth rate. For both sets of data, a negative correlation occurs between growth and biomass (**Figures 13 a and b**) which indicates dependance of growth on population density, as a result probably of interspecific competition. Weak negative correlation can be seen also between the condition factor (C_f) and biomass ($r = -0.52$). This result disapproves the assumption made by Ivanov and Marinov (1992) of the existance of a positive relationship between C_f and the biomass derived from CPUE data. As one can see later on, CPUE is not a representative index of the stock size, due to the strong variability of the catchability coefficient (q) and its dependence on biomass.

TABLE 44. Growth parameters of sprat in Bulgarian waters

Year	L_∞	k	ϕ'	L_1	L	C_f**
1977	12.62	0.329	1.719	0.89	10.59	-
1978*	30.73*	0.042	1.598	0.89	10.13	0.58
1979	14.30	0.271	1.744	1.31	10.17	0.553
1980	16.85	0.145	1.615	1.04	10.67	0.587
1981	12.41	0.594	1.961	1.79	10.40	0.614
1982	12.80	0.427	1.845	1.48	10.23	0.616
1983	13.21	0.344	1.778	1.37	10.10	0.585
1984	12.02	0.544	1.895	1.44	10.27	0.588
1985	13.50	0.282	1.711	1.27	9.80	0.596
1986	12.65	0.404	1.811	1.49	9.80	0.576
1987*	26.03*	0.069	1.670	1.19	9.27	0.581
1988	19.36	0.129	1.684	1.39	9.57	0.554
1989	15.34	0.230	1.733	1.57	9.06	0.568
1990	12.27	0.399	1.770	1.45	9.10	0.593

* - Growth of this cohort is linear, so it is not adequately modelled by the VBGF

** - Data for 1978-1988 are from Ivanov and Marinov (1992)

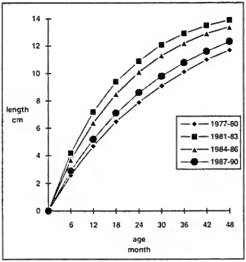


FIGURE 12. Growth curves for average cohorts 1977-1980; 1981-1983; 1984-1986; 1987-1990

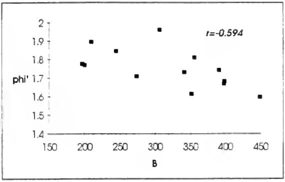


FIGURE 13a. Plot of the growth performance index (phi') from Bulgarian data on the mean biomass (B, in tonnes x 10^{-3})

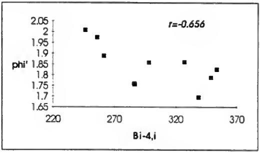


FIGURE 13b. Plot of the growth performance index (phi') from YugNIRO TS date on the mean biomass for the previous 5 years (B_{i-4}, in tonnes x 10^{3})

Tha relationship between sprat growth and various environmentel peremeters is explored in more detail by Daskalov end Prodenov (1994).

Applying different theoreticel end empirical reletions (Alegereye, 1984; Hoenig, 1982; Rikhter and Efanov, 1976; Pauly, 1980 - in Sparre, 1989) plece the values of M between 0.85 and 1.3 (a-1); or on avarage eround 1.0. Thesa values ere rether close to those reportad by Bailay (1980) for the North Sea spret - 0.8-1.2. The ebove methods give only superficiel idea of the theoretical order of magnitude for tha instantaneous coefficient of natural mortelity for certain populetion or species. One mey presuma that the reel values show significent variebility, annuelly and seesonally, as well es between ages.Thus, Ivenov (1983) and Effimov *et al.* (1985) assume variable neturel mortality with age and Prodenov *et al.* (1994) veriable mean ennuel values of the coefficient during the period 1957-1973. In the prasent work two periods ere considered seperetely: prior to end eftar 1974, that differ as to the state of the fish component of the ecosystem, and the place the sprat occupies in it; (as judgad by tha interralations of tha landings of diffarant fish spacias), as wall as by the extent and character of sprat exploitation. The analysed date files for the two periods are rather different. Prior to 1974 complete mackerel extinction and strong reduction of bonito end bluefish landings era recorded, while during the 1960s and the eerly 1970s these were major species for fishery. Stoyanov (1965) paid attention to a probable predator-prey relationship betwaen spret and mackerel, end between sprat and dolphins. In 1974-1976 the trewl-sprat fishery began and intensified later on.

The calculations obtained by the regression analysis (extreme values were excluded from the enelysis) wara the following: for 1953-1973 - M = 1.193 (r = 0.534) end for 1976-1992 - M = 0.98 (r = 0.499) (Fig.14 a, b). The velue astimated for the second period is quita close to that used so far. For comparison with previous investigations M = 0.95 was used as input valua for VPA during 1974-1993. During 1953-1973 a meen ennuel value of M = 1.19 for the parent stock was adopted.

Applying varying coefficients by age end between years supposes meny assumptions, end may lead to e large arror. When en eppropriete astimete of M is usad, e mean valua "buffers" tha unmeasured interannual veriability with age, thus meking the results lass sensitiva to the options of antry parameters. Wa consider that the problam of aga and intarannual variability of sprat natural mortality needs additional clarifying for the purpose of this study, we heve used constent ennuel coefficients).

As was already pointed out, the estimation of M for 0+ to 1 year of age is different more due to scarce date and a supposed great fluctuation of mortality in the eerly ontogenetic stagas. The velue used up to now of M = 0.56 (Ivanov, Beverton, 1985) has baen derived on tha basis o[f] the theoratical relationship between survival and age.

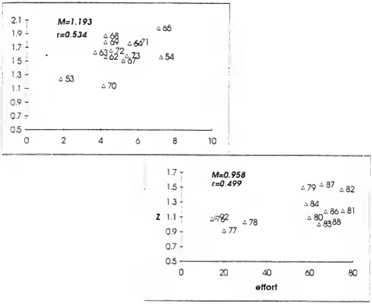


FIGURE 14. Sprat: plot of Z vs effort: a - 1953-1973; b - 1976-1992

The equation we have used is also founded upon assumptions based on the theory of size composition of ecological communities (Kerr, 1974), but it well approximetad tha empiricel data for different species end siza of fish and thair larvae. Although the euthors warn that the relationship derived shows only the common trend in the ecosystem and has not to ba used for astimation of natural mortality coefficients for different fish species, the result obteined for sprat: M = 0.719, appeers quite reelistic (the equetion wes transformed for calculation of M from 1.07 to 31.12 (a): $M = 0.96 * w^{0.25}$ for w= 3.17 g. Moreovar tha basic source of mortelity is the rapacity as in the cese of fish larvae. Besides, the ebove equation epproximates best to data for sizas 0.01 to 10.00 g; the range of weights thet most fish larvae lie within.

Sinca the two estimates, 0.56 and 0.72 are rather suspicious and the choice between them difficult their mean value, M = 0.64, was usad for VPA.

Tha analysis of data for catch at aga end fishing effort was carried out using the three methods described above. As plots of fishing mortality and selectivity by age varied in tima, constant values were assumed for specified periods, and corresponding proportions of selectivity for the last age in comparison with previous ones, were used for tuning the model. The results are described in **Tables 45, 46, 47, 48** and **Figuras 15, 16** and **17**.

TABLE 45. Fishing mortality at aga resulting from Extended survivors analysis (Shepherd, 1994)

year age	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0164	0.0049	0.0031	0.0015	0.0000	0.0113	0.0090	0.0000	0.0012	0.0000
1	0.0266	0.0290	0.1924	1.6309	0.0857	0.3114	0.4805	0.0859	0.0154	0.0369	0.0167	0.0251	0.0605	0.2212	0.1717
2	0.5108	0.0273	0.0812	1.4931	1.5509	0.1910	0.0596	0.2809	0.1661	0.0356	0.0528	0.0682	0.0500	0.1442	0.1925
3	0.2687	0.0281	0.0082	0.0937	0.0491	0.0151	0.0162	0.0110	0.2987	0.1220	0.0145	0.0447	0.0390	0.0316	0.0423
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0110	0.0048	0.0078	0.0085	0.0132	0.0136
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
F1-3/	0.2687	0.0281	0.0939	1.0726	0.5619	0.1725	0.1854	0.1259	0.1601	0.0514	0.0280	0.0460	0.0498	0.1323	0.1355
F2-3/	0.3898	0.0277	0.0447	0.7934	0.8000	0.1031	0.0379	0.1460	0.2324	0.0562	0.0337	0.0565	0.0445	0.0879	0.1174
FC	0.4102	0.0286	0.1806	1.6227	1.1852	0.2642	0.4550	0.1663	0.1638	0.0514	0.0234	0.0332	0.0574	0.2060	0.1743

year age	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	0.0000	0.0097	0.0085	0.0011	0.0019	0.0004	0.0006	0.0005	0.0004	0.0000	0.0000	0.0007	0.0037	0.0060	0.0013
1	0.1172	0.0566	0.1746	0.0838	0.0656	0.0643	0.0124	0.0144	0.0200	0.0079	0.0115	0.0143	0.0634	0.1706	0.3076
2	0.0266	0.0723	0.1624	0.1726	0.0880	0.1532	0.2545	0.0429	0.0133	0.0362	0.0500	0.0664	0.0891	0.3973	0.5995
3	0.0433	0.0145	0.0790	0.0589	0.0494	0.0704	0.1398	0.2782	0.0065	0.0186	0.0409	0.1061	0.2609	0.3425	0.3252
4	0.0062	0.0048	0.0139	0.0105	0.0122	0.0173	0.0244	0.0201	0.0099	0.0274	0.0455	0.0863	0.1312	0.3454	0.3283
	0.0062	0.0048	0.0139	0.0105	0.0122	0.0173	0.0244	0.0201	0.0099	0.0274	0.0455	0.0863	0.1312	0.3454	0.3283
F1-4	0.0624	0.0478	0.1387	0.1051	0.0677	0.0960	0.1356	0.1118	0.0133	0.0225	0.0370	0.0683	0.1362	0.3140	0.3902
F2-4	0.0350	0.0434	0.1207	0.1158	0.0687	0.1118	0.1972	0.1606	0.0099	0.0274	0.0455	0.0863	0.1604	0.3617	0.4177
FC	0.1097	0.0483	0.1552	0.1112	0.0673	0.0969	0.2052	0.1351	0.0174	0.0252	0.0371	0.0637	0.1123	0.2617	0.3972

year age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
	0.0053	0.0015	0.0006	0.0004	0.0005	0.0008	0.0010	0.0002	0.0063	0.0157	0.0045	0.0005	0.0072
1	0.4063	0.8458	0.3399	0.3247	0.2145	0.1788	0.2160	0.2747	0.6023	0.7252	0.1893	0.1039	0.1013
2	0.6155	0.5433	0.4194	0.1924	0.3120	0.2475	0.3635	0.1475	0.6286	0.9094	0.3302	0.3005	0.2053
3	0.6879	0.1954	0.3260	0.3983	0.1558	0.7505	0.3978	0.2028	0.9677	1.8507	0.0526	1.2647	0.1559
4	0.4699	0.3714	0.3184	0.2579	0.2252	0.4095	0.2962	0.3418	0.8885	0.8913	0.1391	0.2658	0.1253
	0.4699	0.3714	0.3184	0.2579	0.2252	0.4095	0.2962	0.3418	0.8885	0.8913	0.1391	0.2658	0.1253
F1-4	0.5449	0.4890	0.3509	0.2933	0.2269	0.3966	0.3184	0.2417	0.7718	1.0942	0.1778	0.4837	0.1470
F2-4	0.5911	0.3700	0.3546	0.2829	0.2310	0.4692	0.3525	0.2307	0.8283	1.2171	0.1740	0.6103	0.1622
FC	0.4639	0.8004	0.3562	0.3108	0.2390	0.3035	0.2753	0.2566	0.6127	0.7657	0.2250	0.5014	0.1332

TABLE 46. Average fishing mortality (A.) and selectively (B.) over different periods in which exploitation pattern is assumed to be constant

A.

Year	1951-52	1953-58	1959-63	1964-69	1970-73	1974-93
F0+	0.000	0.004	0.004	0.003	0.001	0.003
F1	0.028	0.464	0.031	0.138	0.039	0.256
F2	0.269	0.609	0.075	0.128	0.135	0.323
F3	0.148	0.032	0.104	0.045	0.134	0.425
F4	0.000	0.000	0.006	0.010	0.019	0.299
F+	0.000	0.000	0.000	0.000	0.000	0.298

B.

Year	1951-52	1953-58	1959-63	1964-69	1970-73	1974-93
S0+	0.000	0.007	0.042	0.025	0.006	0.007
S1	0.103	0.762	0.298	1.000	0.291	0.602
S2	1.000	1.000	0.718	0.934	1.000	0.760
S3	0.552	0.053	1.000	0.327	0.999	1.000
S4	0.000	0.000	0.062	0.075	0.137	0.702
S+	0.000	0.000	0.000	0.000	0.000	0.701

TABLE 47. Stock numbers-at-age (x10 ^{6}) resulting from XSA

Year age	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1981	1962	1963	1964	1965
0 +	30469	9559	5636	20062	28430	22029	63348	91799	79662	96230	76211	41662	27469	58720	24362
1	105308	16066	5039	2972	10578	14991	11427	33240	48142	41941	50742	39735	21771	14582	30925
2	34	31196	4746	1265	177	2954	3340	2150	9280	14422	12297	15181	11789	6354	3556
3	164	6	9224	1331	86	11	742	957	494	2391	4234	3549	4314	3448	1674
4	0	0	0	0	0	0	0	0	0	111	644	1270	1032	1278	1017
+ gp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	135973	56826	26644	25629	39272	39985	78857	128147	135578	155095	144127	101397	66375	84383	61533
N1 +	105505	47268	19009	5568	10842	17956	15510	36048	57916	58865	67917	59734	38906	25663	37171

Year age	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0 +	19971	13673	12055	29027	24521	110009	130643	170499	113123	85133	115158	84367	84115	97681	72204
1	12846	10531	7141	6302	15287	12905	57983	68844	89826	59627	44890	60721	46375	44192	51200
2	7924	3476	3028	1824	1764	4355	3682	17423	20631	34051	22879	17162	24192	16834	14411
3	892	2347	984	783	467	491	1137	868	5045	7873	12701	8417	6578	8558	4376
4	488	260	704	277	225	135	139	301	200	1938	2989	4715	3070	1960	2350
+ gp	0	0	0	0	0	1	0	1	0	170	179	85	435	71	537
TOTAL	42121	30287	23910	38214	42263	127897	193584	257936	228824	188793	198796	175467	164764	169295	145077
N1 +	22150	16614	11855	9186	17743	17888	62941	87437	115701	103660	83638	91100	80649	71614	72873

Year age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0 +	43046	57918	76085	113061	169236	102358	116641	62693	26188	47606	50108	82694	107690
1	38022	22578	30493	40097	59590	89194	53928	61446	33052	13722	24712	26304	43582
2	14559	9795	3748	8395	11208	18597	28847	16804	18056	6999	2570	7909	9169
3	3060	3042	2200	953	2679	3173	5615	7756	5608	3724	1090	714	2265
4	1223	595	968	614	248	887	579	1459	2449	824	226	400	78
+ gp	763	362	320	61	0	0	0	0	0	0	0	29	0
TOTAL	100672	94290	113814	163181	242960	214208	205611	150157	85353	72876	78707	80257	142856
N1 +	57626	36372	37729	50120	73724	111851	88970	87464	59165	25269	28598	35356	35165

TABLE 48. Recruitment, r (in Nx10^{9}); overall fishing mortality, FC; , and parent stock biomass, B1 + (in tonnes x 10-3) obtained by three alternative methods: Separable VPA (VPSep), VPA with ad hoc tuning (VPtun) and XSA

Year	VPsep			VPtun			XSA		
	R	FC	81 +	R	FC	81 +	R	FC	81 +
1951	29.07	0.025	430.8	30.47	0.032	384.7	30.47	0.032	274.8
1952	15.63	0.029	173.6	9.56	0.028	235.3	9.56	0.028	168.1
1953	8.77	0.109	96.3	5.64	0.151	119.8	5.64	0.151	85.6
1954	7.08	0.787	25.5	20.06	1.546	26.0	20.06	1.546	18.6
1955	12.01	0.264	12.7	28.43	0.311	35.6	28.43	0.311	25.4
1956	31.67	0.871	16.6	22.03	0.264	56.5	22.03	0.264	40.4
1957	34.15	0.285	39.6	63.35	0.455	56.4	63.35	0.455	40.3
1958	1620.0	0.160	62.7	91.80	0.166	144.0	91.80	0.166	102.9
1959	54.12	0.177	57.8	79.66	0.164	230.1	79.66	0.164	164.4
1980	118.00	0.121	105.4	96.23	0.051	277.8	96.23	0.051	198.4
1961	64.12	0.039	223.6	76.21	0.023	324.0	76.21	0.023	231.5
1962	54.09	0.034	186.1	41.66	0.033	284.7	41.66	0.033	203.3
1963	52.04	0.049	154.5	27.47	0.057	199.1	27.47	0.057	142.2
1964	46.49	0.108	127.6	59.06	0.206	127.0	58.72	0.206	91.8
1965	31.14	0.207	104.8	23.66	0.176	140.6	24.36	0.174	101.5
1966	19.26	0.084	89.1	20.35	0.113	107.4	19.97	0.110	78.3
1967	12.80	0.045	60.9	13.31	0.048	80.8	13.67	0.048	57.9
1968	12.06	0.167	42.3	11.10	0.158	60.2	12.05	0.155	43.5
1969	44.15	0.119	33.2	25.20	0.117	44.2	29.03	0.111	33.2
1970	23.27	0.055	78.4	20.12	0.076	69.9	24.52	0.067	56.4
1971	99.92	0.074	76.1	77.99	0.114	77.4	110.01	0.097	65.8
1972	171.00	0.218	172.0	88.63	0.256	184.5	130.64	0.205	181.2
1973	288.00	0.159	341.0	125.00	0.178	277.3	170.50	0.135	287.4
1974	140.00	0.011	624.8	76.00	0.024	410.8	113.00	0.017	409.7
1975	68.39	0.017	790.5	70.83	0.035	539.3	85.13	0.025	553.5
1976	74.82	0.028	548.6	89.64	0.057	490.3	115.00	0.037	469.1
1977	68.27	0.060	417.8	71.88	0.092	522.3	84.37	0.064	485.9
1978	74.92	0.147	321.9	76.25	0.144	463.6	84.12	0.112	412.7
1979	82.04	0.344	293.6	85.17	0.312	434.6	97.68	0.262	370.1
1980	68.10	0.445	267.9	63.96	0.423	395.6	72.20	0.397	332.9
1981	47.35	0.508	243.7	38.78	0.502	338.2	43.05	0.464	280.9
1982	57.66	0.616	205.8	50.98	0.808	255.3	57.92	0.800	209.2
1983	89.95	0.314	188.4	69.42	0.383	224.6	76.09	0.356	184.6
1984	120.00	0.236	269.6	134.00	0.325	293.9	113.00	0.311	234.7
1985	162.00	0.193	350.2	152.00	0.225	476.8	169.00	0.239	313.2
1986	88.68	0.226	405.8	84.67	0.311	551.4	102.00	0.304	397.8
1987	104.00	0.273	378.0	102.00	0.289	507.6	117.00	0.275	398.7
1988	50.00	0.270	359.4	49.54	0.277	488.1	62.69	0.257	398.6
1989	28.26	0.721	239.9	23.60	0.736	324.3	26.19	0.613	284.8
1990	47.53	0.790	100.0	50.81	0.877	125.9	47.61	0.766	115.0
1991	59.36	0.187	71.1	61.08	0.228	98.1	50.11	0.225	73.1
1992	38.36	0.317	109.6	82.69	0.559	156.8	82.69	0.501	99.4
1993	93.50	0.127	106.0	93.50	0.109	194.5	108.00	0.133	156.2

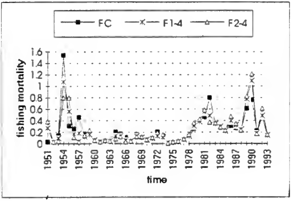


FIGURE 15. Trends in yearly fishing mortality : F_c -average weigthed by yield/recruit-at-age; F1-4 and F2-4 unweighted means over ages 1-4, 2-4

From **Figure 16** and **Table 48** it is seen that these methods give the most pronounced difference for years with maximum biomess. In broad outline XSA showed intermediate values during this period and due to the high methodological reliability of the method, its results were used for further analyses. Nevertheless, it is not excluded that for some time periods, the estimates by the other two methods may be closer to the real values.

The pattern of stock evolution shows conspicuous cyclic recurrence. In the early 1950s 20-40 thousand tonnes decreased and remained at the level till 1957. During the next 10 years period an increase to 231 thousand tonnes in 1961, and then declines in biomass were recorded. From the middle of the 1960s until the early 1970s, the stock size was low (30-70 thousand tonnes). In the early 1970s an increase began which, during 1975-1977, led to record high values (around 400-800 thousand tonnes according to different methods). Until the beginning of the 1980s, a gradual decline in the biomass followed with a minimum in 1983, but the stock was still considerably higher than during earlier periods of depression. The rise during 1986-1988 was followed by a sharp decline and ettained its minimum in 1991, when the stock reached figures characteristic for the 1960s (about 70 thousend tonnes). Since 1991, a tendency to increase has been noticed. The contribution of age groups to the stock size can be seen from **Table 47** and **Figure 17.** Usually the high values of recruitment were followed in sequence by peaks for stock in age groups 1 and 2 year old fish, 3 and 4 year old participated more appreciably in the years of revival and immediately after (mostly since 1972). The estimates of sprat biomass are akin to those reported by Prodanov *et al.*, 1994 (**Figure 18**).

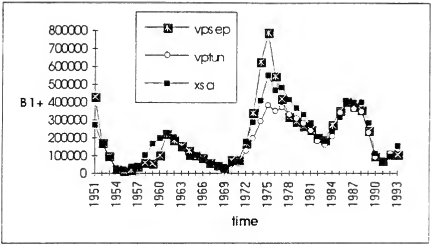


FIGURE 16. Sprat biomass (in tonnes) over the years obtained by three methods: Separable VPA; VPA with ad hoc tuning (vptun); XSA

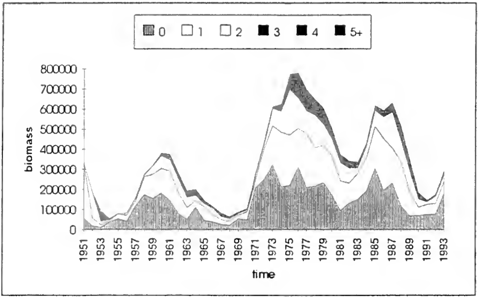


FIGURE 17. Sprat biomass-at-age (tonnes) over years from XSA

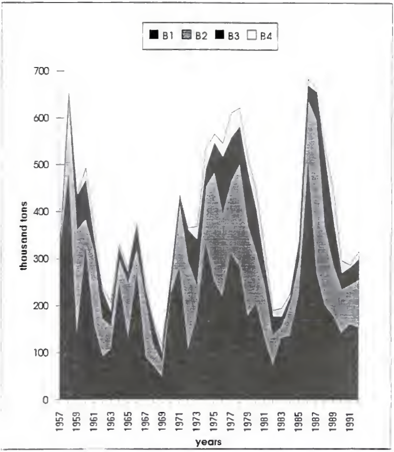


FIGURE 18. Sprat spawning biomass (by age groups) in the western part of the Black Sea during 1957-1992 (aftar Prodanov *et al.*, 1994)

The observad cyclic biomass dynamics argua for a stock sansibility to natural anvironmantel parameters, although the fishing effort obviously reinforces natural trends and may also have had a dominant impact in causing stock declines. The results show that F strongly varied between the different ages, due mainly to veriabla yaar class strength end changes in the susceptibility of the different cohorts to the fishery (**Table 45**). This veriability created conditions for significant increases in fishing mortality in particular years (for instance during 1954-1957, though these values are unrealistically high and probably ere en artefect, as e result of errors in ege determinetion). The average plots of mortality end selectivity at age (**Tabla 46**) also show that in certain periods different age groups (1, 2 or 3 year old fish) have supported peak exploitation. From **Figure 15 it saems** that the major pariods of enhanced fishery mortality coincidad or precaded the minima for biomass (1954-1957; 1964-1966; 1980-1982; 1989-1990). The reason for this phenomenon may be both the momentum of fishing effort (the fishing effort remains high for some tima even after the catch decline due to the persistenca of tha fleet capacitias introduced to tha fishary and tha need for the implementation of the economic plan) and the specificity of school behaviour (with catchability showing a nagetive dependance on stock siza). High fishing mortality is an especially important factor during times of negative changes in the stock abundance.

Since 1988, a sharp decline of sprat biomass accompanied a fishing mortality increase in 1989 owing to the high fishing effort in the sprat fishery of the former USSR (record high catches of sprat were recorded in 1989). During 1989-1991 the *Mnemiopsis* biomass had also reached maximum values. Up to date there is no direct evidence that the ctenophore feeds on sprat larvae, which is one reason why one may not assert that it was the cause of the weak 1989-1991 year classes. Nevertheless, some data for vertical distribution offshore during the cold season when the spawning peak occurs and a seasonal maximum of the *Mnemiopsis* biomass was observed (Vinogradov *et al.*, 1992); this provides a reason to consider the ctenophore as a possible factor in negative changes in sprat stocks.

Up to now the relationship between plankton-feeding invertebrates and fish was regarded as one way, i.e. the former were pointed out as the reason for the stock decline of the latter. In our opinion, it is possible to postulate a reverse impact: the lowering of fish stocks owing to a heavy and unadjusted fishery may result in a surplus of zooplankton that would favour "outbursts" of megaplankters. In diminishing their biomasses, fish populations respond by enhanced growth rate and condition (owing to increased food availability), as well as by active reproduction and "rejuvenating" of the stock, effects that have occurred for sprat during the period 1991-1993.

The pronounced cyclical recurrence in sprat population dynamics permits comparisons with stock dynamics of other abundant fish species in the World Ocean and argue for some global determination concerning the stock as well as the whole ecosystem, as influenced primarily by climatic factors (Mann, 1993; FAO, 1994). On the other hand, the results obtained by us also indicate the essential influence of two conjugated factors since the beginning of the 1970s, resulting from human activities (over exploitation and eutrophication).

Regardless of the high reproductive potential of sprat populations and existing opinions that the stock is under- exploited, the peculiarities of the ecology and behaviour of this small pelagic species can easily lead to situations with over-exploitation and decreases of the stock. Of the characteristics considered in this work are: the wide variation of recruitment and its sensibility to environmental factors, as well as the reverse stock dependent catchability, owing to enhanced availability of the stock to the fishery even at reduced stock size. Thus the cumulative occurrence under certain circumstances of unfavourable environmental conditions and high fishing mortality, stress the weak "buffer capabilities" of the species due to short age composition = small number of age groups determining the parent stock and enhanced total mortality.

It is of no less concern that the fishermen's activities from those countries exploiting the stock, despite the long existence of the Joint Fishery Commission for the Black Sea, have not led to an organised international research group for conducting a generalised stock assessment; the only way that scientifically founded fishery regulation can be achieved.

The other group of factors having negative influence on the fish populations, is related to negative changes due to the eutrophication. After the initial positive effect, the so-called eutrophication-enhanced fishery production, there follows a period with sharp fluctuations in biota parameters, raised frequency and intensity of plankton blooms, hypoxia, changes in community structure. The greatest impact on the small pelagic fish appears to be through the hyper-productivity of the plankton eating megaplankton.

At present the Black Sea ecosystems and fish in particular are subjected to the impact, both of the natural environmental factors and of increased anthropogenic activities. The cumulative action of these factors has to be considered in order to find an explaination for the chaotic behaviour of the system during the past decades. As it was already stated, small pelagic populations are of utmost significance for the ecosystem "health", because of their place in the trophic web, which makes possible their control of upper and lower trophic levels, as well as the fact that they are the link for a direct anthropogenic impact through the fishery.

BLACK SEA HORSE MACKEREL, *TRACHURUS MEDITERRANEUS PONTICUS* ALEEV

The Black Sea horse mackeral is a subspecies of the Mediterraneen horse mackerel, *Trachurus mediterraneus*. Aleev (1957, 1959) considers thet in the Black Sea tha species is represented by four local subpopulations: the south-western (Bosporic), the northern (Crimeen), the eastern (Ceucasian), and tha southarn (Anatolian), aach one with its own biological characteristics like wintering grounds, fat content, spewning patterns, age composition, growth rete, feeding petterns, etc. On the basis of investigetions carried out by Georgiev end Kolerov (1959, 1962) on size composition, and also tagging axperiments of horse meckerel caught off the Bulgarian coast, they concludad thet in the Black Sea two subpopulations occur that belong to the small size - type of *Trachurus mediterraneus ponticus*, the eastern end western onas, respectively. Although the two subpopulations are mixing at the edge of their distribution arees, they have the same behaviour end biology.

According to the Romanien meristic enelyses (Ceutis, 1966; Cautis and Jonascu, 1961, 1979) in the westarn and north-western pert of the Bleck Sea there exists a single "group" of horse meckerel. For the eastern part Cosswig (1955) and Numenn (1956) suggest that the smell and large types are in fact different age groups from the seme stock. Shaverdashvily (1976) asserts that tha large horse mackerel can be found in period of strong year classes of anchovy and they belong to the seme species end stock. On the other hand the existence of two different subspecias of *Trachurus mediterraneus* in the Black Sea is supported by Altukhov and Apekin (1963) from serological analyses, by Altukhov end Michalev (1962) by means of the cherecteristics of the celluler tharmal stability, and also by Schulman (1972) who used yeerly rings on diffarent hard structures. Dobrovolov and Dobrovolova (1983), using electrophoretic methods, assumed that no difference at species level can be found between *Trachurus mediterraneus ponticus* end *Trachurus mediterraneus mediterraneus*. For this raason according to Dobrovolov (1985) the large-sized type occurrence can be expleined es e result of e heterosis effact betwean tha ebova-mentioned subspecies. This type being sterile does not produce further offspring, and beceme extinct after completing its life span.

In our opinion tha Bleck Sea horse mackerel represents e singla population, es the environmental conditions ere elmost one end the same in the whole eree inhebited, end there exists no positive evidence for the occurrence of two distinct subpopulations differing substantially in their biologicel parameters.

Tebla 49 shows Black Sea horse mackerel catches by countries during the period 1950-1994 (smell type only).

TABLE 49. Black Sea horse mackerel landings (in tonnes) during the period 1950-1994

Years	Bulgaria	Romania	former USSR	Turkey	Total
1950	644.4	217.0	6230.0	1200.0	8291.4
1951	736.2	293.0	1870.0	2500.0	5399.2
1952	564.9	260.0	3050.0	2600.0	6474.9
1953	294.7	140.6	1650.0	9200.0	22094.7
1954	593.2	617.8	1600.0	12200.0	25511.2
1955	662.4	297.4	500.0	7200.0?	19950.4
1956	131.5	63.5	200.0	14200.0?	29734.5
1957	69.4	119.7	200.0	14000.0?	26919.4
1958	233.0	587.4	220.0	4900.0	17370.0
1959	687.4	839.8	2110.0	700.0	12687.4
1960	1017.7	674.6	6240.0	4800.0	17691.7
1961	1240.6	2200.0	5720.0	3600.0	16345.6
1962	805.2	1166.0	13700.0	13500.0	29271.2
1963	231.4	532.0	13900.0	3500.0	18163.4
1964	242.0	248.4	10200.0	3100.0	13790.0
1965	301.6	1364.7	5240.0	1200.0	8106.3
1966	556.7	1770.0	2350.0	600.0	5276.7
1967	245.7	762.0	6489.0	24615.0	32111.7
1968	37.4	175.0	4750.0	15162.0	20124.4
1969	95.9	156.0	1280.0	16762.0	18293.9
1970	689.1	1342.0	630.0	19380.0	22041.1
1971	630.9	1218.0	4350.0	8722.0	14920.9
1972	534.0	500.0	21820.0	10855.2	33709.2
1973	849.0	606.0	10780.0	16593.7	28828.7
1974	2168.8	608.0	2883.0	10244.8	15904.6
1975	1972.8	1003.0	4335.0	11897.8	19208.6
1976	1808.7	1514.0	18345.0	14077.9	35745.6
1977	791.0	404.0	4707.0	14674.3	20576.3
1978	565.0	729.0	685.0	23529.0	25508.0
1979	934.5	1179.0	734.0	59772.0	62619.5
1980	813.0	1536.0	609.0	42339.0	45297.0
1981	476.2	588.0	344.0	40543.0	41951.2
1982	366.8	291.0	1875.0	48918.0	51450.8
1983	496.7	1510.0	7157.0	54548.0	63711.7
1984	1015.8	872.0	5502.0	69980.0	77369.8
1985	755.8	1035.0	38870.0	100417.0	141077.8
1986	850.9	945.0	2370.0	100943.0	105108.9
1987	826.4	997.0	543.0	90850.0	93216.4
1988	1676.8	2660.0	398.0	93006.0	977408
1989	1100.9	1459.0	305.0	94023.0	96887.9
1990	164.1	165.0	56.0	65163.0	65548.1
1991	122.9	48.0	3.0	19781.0	19954.9
1992	54.0	22.0	0.0	17524.0	17600.0
1993	31.0	22.0	0.0	5000.0	5053.0
1994				15000.0	15500.0*

* - the total catch is enlarged by 500 tonnes for 1994 since the fishery statistics for all Black Sea countries, except Turkey, are underestimated.

Generally, the horse meckerel fishery is carried out by active (bethypelegic trewls end surrounding nets), and by passive (trap nets) geers. The Bulgarian end Romanian cetches are taken primarily by pessive, while the Turkish end former USSR entities by active gears.

Teble 50 presents the age composition of horse meckerel cetches during the period 1950-1994.

TABLE 50. Age composition (x 10^{-6} specimens) of total horse meckerel catches in the Bleck See during 1950-1954 (W = meen weight fish in cetches, g)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	Total	W
1950	523.3	198.9	62.4	35.3	3.1	0.4	0.0	823.4	10.07
1951	1.4	214.8	64.4	87.5	3.9	0.3	0.1	362.4	14.9
1952	0.1	130.8	104.4	39.3	11.3	2.7	0.2	288.8	22.43
1953	812.4	617.5	247.8	109.5	86.4	8.4	51.3	1833.3	12.05
1954	801.3	823.3	305.4	156.5	81.1	11.7	4.8	2084.1	12.24
1955	703.6	483.7	302.8	164.8	83.8	28.5	2.3	1749.1	11.41
1956	994.1	866.2	288.8	179.2	88.7	29.6	1.8	2446.4	12.15
1957	1083.9	935.4	317.9	106.4	78.6	32.8	4.4	2559.2	10.52
1958	424.8	765.2	214.6	117.3	18.8	15.4	0.1	1568	11.18
1959	77.3	415.4	404.3	70.1	18.5	4.4	0.5	990.5	12.81
1960	146.6	114.2	300.6	141.1	31.4	7.2	1.6	742.6	23.82
1961	10.1	566.8	81.5	132.4	51.4	4.7	1.1	848	19.28
1962	182.6	403.9	572.9	66.3	98.1	26.4	2.4	1352.6	21.57
1963	89.9	93.9	417.4	295.1	35.5	41.3	12	985.1	18.44
1984	4.9	42.1	164.3	222.3	96.2	10.4	8.2	548.4	25.14
1965	83.3	97.4	111.8	76.5	91.6	17.6	3.3	461.5	17.56
1968	0.1	89.3	58.3	52.7	11.5	2.7	6.4	221.0	23.88
1967	0.2	149.9	948.7	192.2	36.3	38.6	2.9	1368.8	23.46
1988	0.1	188.6	207.3	496.7	59.0	12.4	0.1	964.2	20.87
1969	135.0	491.3	88.2	141.4	217.5	21.8	0.3	1095.5	18.70
1970	0.2	604.5	352.8	73.3	63.2	104.2	0.4	1198.8	18.39
1971	0.3	0.7	486.6	100.3	11.1	1.5	0.7	601.2	24.82
1972	82.6	132.7	173.1	771.4	27.2	2.5	1.2	1170.7	28.79
1973	0.5	130.0	100.9	89.2	445.3	2.2	0.3	768.4	37.62
1974	27.6	45.8	33.7	18.7	5.1	343.5	3.3	477.7	32.29
1976	0.3	30.9	1060.9	100.2	12.1	2.4	4.1	1200.9	29.77
1977	0.2	29.0	102.3	411.6	57.2	6.4	7.5	614.2	33.50
1978	38.4	790.8	102.0	89.8	227.8	14.0	1.1	1264.0	20.18
1980	0.8	139.1	887.2	130.8	316.8	185.8	64.3	1503.8	30.12
1981	200.0	228.9	335.8	715.9	64.8	116.3	22.0	1683.7	24.92
1982	898.3	600.3	602.5	283.9	337.5	48.6	65.0	2634.1	19.53
1983	15.5	17.2	1991.2	219.4	92.6	38.7	2.9	2375.4	28.82
1984	84.9	609.2	419.2	1840.7	62.1	7.0	2.1	2825.2	27.39
1985	47.7	218.3	4438.2	383.4	85.9	22.1	3.4	5199.0	27.14
1986	0.8	61.4	69.9	2664.2	403.6	25.0	22.3	3247.2	32.37
1987	34.3	51.4	256.5	51.7	2083	118.2	16.9	2590.0	35.99
1988	481.9	3864.5	1189.4	127.9	81.4	197.9	19.8	5962.8	16.39
1989	59.7	86.3	1878.1	958.8	101.4	68.3	243.6	3396.2	28.53
1990	6.5	41.1	73.1	1362.7	392.2	62.3	16.3	1943.2	33.73
1991	0.3	190.0	249.2	77.0	159.0	44.0	3.8	723.1	27.60
1992	0.4	25.5	611.8	46.3	23.2	14.6	2.3	624.1	28.20
1993	0.2	19.1	45.1	124.9	4.8	1.0	0.3	196.2	26.89
1994	11.6	45.4	183.6	295.2	47.1	1.7	0.2	584.8	26.50
Average	176.8	362.4	473.4	319.6	147.8	41.5	15.2	1536.7	22.80

On the basis of these data VPA was F_{st} and these values were calculated as the difference between the mean values of Z and M. The coefficient Z was estimated by regression of the age composition. The usual iterative procedure was next to minimize the errors arising on determining the values of F_{st}. As it was pointed out, 10 iterations of F values were performed by age group.

The mean value of M was obtained by Kutty and Quasim's method (1965). For this purpose the parameters of the von Bertalanffy's equation were estimated as follows:

$$L_\infty = 19.25 \quad t_0 = -0.59142 \quad k = 0.34808$$
$$W_\infty = 73.65 \quad t_0 = -2.26408 \quad k = 0.15663$$
$$n = 1.7170 \quad a = 0.3220$$

Using these data it was established that the mean value of M was 0.40. This value lies in the middle of the interval determined by Ivanov and Beverton (1985) - 0.35-0.45. We applied the value of 0.45 in the VPA analysis mainly for two reasons: the first one assumes that using Pauly's method, based also on the parameters of von Bertalanffy's function, the value of M is considerably higher, around 0.70; the second considers that Black Sea horse mackerel has a shorter life span than other representatives of genus *Trachurus* for which M values ranging around 0.40 have been estimated.

Tables 51 and 52 and Figure 19 show the results of VPA.

TABLE 51. Number of horse mackerel (by age groups x 10^{-6} sp.)in the Black Sea during the period 1950-1995

Years	0+	1,1+	2,2+	3.3+	4,4+	5,5+	6,6+
1950	3411.86	1103.63	424.85	106.96	5.49	1.64	0.00
1951	2881.00	1764.34	554.65	221.85	40.78	1.14	0.38
1952	3967.95	1835.90	995.94	310.79	73.81	22.93	1.70
1953	4859.88	2530.00	1067.41	527.31	167.25	38.19	233.21
1954	3643.34	2460.98	1207.74	486.74	250.45	40.59	16.65
1955	4409.54	1618.50	1082.06	531.40	188.70	96.66	7.80
1995	4418.39	2259.02	655.39	454.04	210.78	70.79	4.30
1957	5891.19	2039.27	770.17	195.40	150.97	67.46	9.10
1958	4663.80	2906.20	580.49	245.66	43.49	36.20	0.24
1959	1420.27	2636.06	1255.32	203.91	66.62	13.24	1.50
1960	5885.72	844.56	1356.43	486.15	75.61	28.05	6.23
1981	3894.94	3637.04	448.70	629.60	200.05	23.97	5.61
1962	2435.39	2475.53	1873.80	222.17	297.75	87.40	7.95
1968	1424.73	1408.81	1261.29	748.94	90.04	113.63	33.02
1964	2230.18	837.48	[illegible]	479.98	249.39	29.96	23.63
1995	8871.59	1418.15	500.75	396.76	135.22	84.59	15.86
1968	[illegible]	5606.66	827.38	231.78	193.01	17.64	41.81
1967	1119.09	1303.45	3504.25	481.56	106.55	113.99	8.56
1968	[illegible]	713.40	713.10	1494.34	158.52	39.76	0.32
1995	27443.86	1707.72	314.18	293.68	572.54	55.73	0.77
1974	1102.80	17392.08	706.07	131.57	78.78	[illegible]	0.76
1971	833.12	703.02	10611.81	180.04	28.08	4.16	[illegible]
1972	1163.38	530.98	447.71	6381.93	38.43	9.32	4.48
1979	6285.72	692.36	234.84	151.57	3462.15	4.25	0.58
1974	12927.11	4007.56	339.52	71.95	29.01	1857.23	17.84
1975	11121.72	8220.83	2519.07	189.93	31.27	14.29	714.11
1976	9449.52	[illegible]	[illegible]	1407.51	105.27	15.78	26.95
1972	5063.50	6025.04	4482.04	2161.13	818.40	57.60	67.50
1978	[illegible]	3228.47	3818.77	2776.96	1055.26	476.70	37.45
1979	3388.16	6001.84	1440.28	2354.29	1699.67	494.42	8.51
1980	4879.30	2160.15	3634.98	558.90	924.17	[illegible]	303.78
1981	16731.11	3110.55	1267.57	1778.89	254.05	344.14	65.10
1982	12445.08	10509.86	1802.77	545.94	581.14	111.35	148.92
1995	50195.58	7385.47	6227.35	681.56	131.15	114.41	9.04
1984	3194.44	31993.84	4695.56	2422.64	264.03	14.70	4.41
1985	3870.28	1969.72	19918.23	2663.54	316.35	119.78	18.43
1986	11795.12	2430.03	1084.04	9226.52	[illegible]	134.71	120.16
1981	20783.40	7520.27	1500.89	636.04	3807.29	576.28	83.81
1984	1609.90	13224.92	4754.44	601.71	364.78	854.61	85.50
1995	1333.96	651.32	5422.28	2101.87	293.60	168.88	602.34
1986	4913.88	803.40	347.42	2000.06	602.29	102.16	29.88
1991	10641.33	3128.08	479.81	164.27	255.72	89.19	7.30
1992	8024.10	6784.97	[illegible]	115.49	45.60	42.99	6.77
1993	4153.80	5116.08	4306.10	777.06	37.86	11.33	3.40
1989	1106.30	2648.42	3247.03	2709.98	397.38	20.52	2.41
1995		696.23	1652.79	1925.41	1495.47	216.31	13.13

TABLE 52. Horse mackerel fishing mortality rate (by age groups) during the period 1950-1994

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+
1950	0.2095	0.2380	0.1997	0.5143	1.1219	0.3564	0.0000
1951	0.0008	0.1828	0.1292	0.6505	0.1258	0.3891	0.3891
1952	0.0000	0.0923	0.1449	0.1697	0.2091	0.1571	0.1571
1953	0.2305	0.2895	0.3353	0.2945	0.9659	0.3147	0.3147
1954	0.3814	0.3717	0.3710	0.4978	0.5021	0.4342	0.4342
1955	0.2188	0.4540	0.4184	0.4747	0.5306	0.4486	0.4466
1956	0.3232	0.8261	0.7802	0.8511	0.6893	0.7052	0.7062
1957	0.2566	0.8065	0.6927	1.0526	0.9780	0.8707	0.8707
1958	0.1194	0.3895	0.5962	0.8550	0.7395	0.7225	0.7225
1969	0.0698	0.2168	0.4986	0.5421	0.4149	0.5191	0.5191
1960	0.0314	0.1825	0.3175	0.4379	0.6986	0.3773	0.3773
1961	0.0032	0.2132	0.2529	0.2988	0.3781	0.2767	0.2757
1982	0.0974	0.2243	0.4671	0.4532	0.5133	0.4601	0.4601
1983	0.0813	0.0861	0.5181	0.6498	0.6502	0.6829	0.6829
1964	0.0027	0.0643	0.2811	0.8169	0.6312	0.5488	0.6488
1965	0.0089	0.0888	0.3203	0.2706	1.5867	0.2951	0.2951
1966	0.0001	0.0200	0.0912	0.3272	0.0766	0.2090	0.2090
1967	0.0002	0.1632	0.4023	0.6612	0.5357	0.5316	0.5316
1988	0.0000	0.3914	0.4388	0.5191	0.6018	0.4788	0.4788
1969	0.0051	0.4332	0.4204	0.8858	0.6183	0.6432	0.6432
1970	0.0002	0.0440	0.9185	1.0944	2.4905	1.0065	1.0055
1971	0.0004	0.0012	0.0585	1.0944	0.6525	0.5763	0.5783
1972	0.0690	0.3658	0.6331	0.1818	1.7528	0.3978	0.3976
1973	0.0001	0.2626	0.7330	0.2034	0.1728	0.9704	0.9704
1974	0.0027	0.0143	0.1309	0.3834	0.2438	0.2581	0.2581
1975	0.0034	0.1135	0.1321	0.1401	0.2341	0.1388	0.1368
1976	0.0000	0.0064	0.3226	0.0922	0.1531	0.2076	0.2076
1977	0.0000	0.0080	0.0287	0.2668	0.0905	0.1478	0.1478
1978	0.0051	0.3572	0.0337	0.0409	0.3082	0.0371	0.0371
1979	0.0001	0.0515	0.4966	0.4851	0.3247	0.4894	0.4894
1980	0.0002	0.0831	0.2646	0.3384	0.5378	0.3010	0.3010
1981	0.0150	0.0955	0.3924	0.6687	0.3749	0.5302	0.5302
1982	0.0718	0.0734	0.5227	0.9762	1.1752	0.7493	0.7493
1983	0.0004	0.0029	0.4941	0.4983	1.7383	0.4961	0.4981
1984	0.0335	0.0239	0.1170	0.5858	0.3404	0.8512	0.8512
1985	0.0154	0.1472	0.3196	0.1954	0.4037	0.2574	0.2574
1986	0.0001	0.0318	0.0832	0.4352	0.4355	0.2591	0.2591
1987	0.0021	0.0085	0.4640	0.1060	1.0440	0.2847	0.2847
1988	0.4549	0.4416	0.3663	0.3026	0.3201	0.3341	0.3341
1989	0.0571	0.1785	0.5473	0.7998	0.5708	0.6732	0.8732
1990	0.0016	0.0655	0.2990	1.6068	1.4599	0.9522	0.9522
1991	0.0000	0.0782	0.9742	0.8316	1.3332	0.8986	0.8985
1992	0.0001	0.0047	0.4145	0.6852	0.9428	0.5338	0.6338
1993	0.0001	0.0046	0.0131	0.2206	0.1625	0.1156	0.1156
1994	0.0131	0.0215	0.0726	0.1445	0.1582	0.1081	0.1081

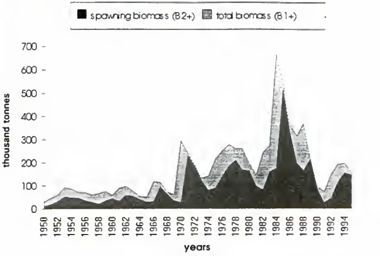


FIGURE 19. Spawning (B_{2+}) and total biomass (B_{1+}) of Black Sea horse mackerel

TABLE 53. Horse mackerel biomass (x 10^{-3} tons) in the Black Sea during the period 1950-1994

Years	(A0+)	(A1+)	(A2+)	Years	(A_{0+})	(A_{1+})	(A_{2+})
1950	54.73	29.10	12.30	1973	180.99	133.90	123.30
1951	67.93	46.30	19.30	1974	239.60	142.70	81.30
1952	90.16	60.40	32.30	1975	300.21	216.80	91.00
1953	129.26	92.80	54.10	1976	322.77	251.90	143.80
1954	114.60	87.30	49.60	1977	317.05	279.10	186.90
1955	105.70	72.60	47.90	1978	332.26	261.30	211.90
1956	103.92	70.80	36.20	1979	287.35	261.90	170.10
1957	105.11	60.90	29.70	1980	235.70	199.10	166.10
1958	101.38	66.40	21.90	1981	272.93	147.50	99.90
1959	86.22	75.60	35.20	1982	337.29	244.00	83.20
1960	103.18	59.00	46.10	1983	650.37	273.90	160.90
1961	119.38	90.20	34.50	1984	689.52	665.60	176.10
1962	115.75	97.50	59.60	1985	573.86	544.80	514.70
1963	88.35	77.70	56.10	1986	456.90	368.40	331.30
1964	70.63	53.90	41.10	1987	471.08	315.20	200.10
1965	118.11	51.60	29.90	1988	380.61	368.50	166.20
1966	133.94	118.60	32.80	1989	234.71	224.70	214.70
1967	124.66	116.30	96.30	1990	136.14	99.30	87.00
1968	93.72	73.70	62.80	1991	154.53	74.70	26.90
1969	267.68	61.90	35.70	1992	210.03	149.80	46.00
1970	303.15	294.90	28.80	1993	224.61	193.50	115.20
1971	250.18	243.90	233.20	1994	206.24	197.90	157.40
1972	202.47	193.70	185.60	1995		156.50	145.89

It is apparent that during the period under consideretion, both the total and spawning biomesses varied widely, owing to the different strength of the naw year clesses. These heve renged during the period 1950-1959 from 1420.27 x 10^6 (1959) to 5891.19 x 10^6 (1957) by number of specimens. During the same period, the totel (B0+) end spewning (B2+) biomesses heve ranged from 54.7 (1950) to 129.3 (1953) thousend tonnes, and from 12.3 (1950) to 54.1 (1953) thousend tonnes, respectively. In the next decade (1960-1969) thase biomasses veried from 76.6 (1964) to 267.9 (1969) end from 29.9 (1965) to 96.3 (1967) thousend tonnes, respectively. It is claar that thara is no coincidence between the totel end spewning biomasses due to the wide fluctuation in the strangth of year classas. Thus, for instance, the size of the totel biomess in 1969 was determined by the strong 1969 year class - 27443.83 x 10^6 (numbers). During tha next three yeers the new yeer clesses were week, especielly thet of 1971 (833.12 x 10^6). As a result, the total stocks declined from 303.2 (1970) to 181.0 (1973) thousend tonnes. Subsequently, they increesed to 332.3 (1978) thousend tonnes. In the late 1970s end the baginning of the 1980s (till 1982 includad), the total biomass ranged from 235.7 (1980) to 337.3 (1982) thousend tonnes. In 1983 end 1984 the indicated biomesses grew to 650.4 end 689.7 thousand tonnes. The reason was the very strong 1983 and 1984 year clesses, especially the first one, with an extreme velue of 50195.58 x 10^6 specimens. However, the next two yeer clesses (1985 and 1986) were weak, resulting in e decline in tha total biomass, becausa of a rise in tha spawning biomass that reachad its meximum value in 1985 - 514.7 thousand tonnes. The successive 1986-1987 year classes were relatively strong (over the everage) end the totel end spewning biomesses remained comparetively high - 456.9-471.1 end 313.3-200.1 thousend tonnes, respectively. Weak successive 1988-1989 year classes - 1609.90 x 10^{-6} and 1333.96 x 10^{-6} caused a sharp decline in the total and spawning biomasses -136.1-154.5 and 87.0-26.9 thousend tonnes in 1990 end 1991, respectively. The 1991-1993 year clesses veried between 4153.80 x 10^6 (1993) and 10641.33 x 10^6 (1991) as a result of which the totel end the spewning biomasses increased to 224.6 and 115.2 (1991) thousend tonnes, respectivaly. The lest 1994 year class wes very weak - 1106.3 x 10^6 specimens. As noted, the estimation of year cless strength during the last 1-2 years, has been quite difficult, end the errors ere probably higher. Neverthelass the spawning biomess seams to remein et the level of 1994 end aven it has dropped from 157.4 to 145.9 thousand tonnes. If the estimated abundance of 1994 year class does not differ seriously from the real value it can be expected that the exploited stock (B1 +) will continue to decline from 197.9 to 156.5 thousend tonnes. As was pointad out, the accurecy of the assessments depends exclusively on the fishery statistical data. Therefore, the lack of information on horse meckeral catches, or its underestimation by Russie, Ukreina, Georgia, Romania and Bulgaria enhances the risk of en incorrect essessment of biomasses. For example, according to Turkish data, the catches in 1994 were threefold higher than in 1993.

As is the cese with enchovy catches, Turkish catches of horse meckerel ere taken primerily in winter when the species has an almost sedentary pattern of life, and forms dense concentretions on the wintaring grounds. This mekes the fishery mora effactiva, and raises the possibility of harvesting larger amounts of fish, for the same stock size.

The improvements of fishing geers end the epplicetion of modern echo-ecoustics further contributa to a more effective fishery. However, this has an immediate effect on the fishing mortality (**Table 52**). When the level of the horse meckerel stock wes low, even smell catches caused higher fishing mortality, and vice versa. For axample, during 1956-1958, catches varied between 17.370 and 29.735, (on average 24.675 thousand tonnes), end the mean value of F_{2-6} veried from 0.7022 to 0.8929; everaging 0.7271. In 1985-1988, the period when this species biomass was higher, cetches of the order of 93.741-141.078 thousand tonnes ceused e fishing mortality in the range 0.2867-0.4367 (average 0.3373). All this stresses the necessity of annual assessments of stock size, of TAC's, as well es of clerifying the ceuses (neturel and anthropogenic) determining fluctuations in year class strength. This problem will be discussed later when the dete on year cless ebundence of horse meckerel, enchovy, spret, whiting end others species considerad, will be juxteposed to those of the environmental peremeters which influanca tha trophic capacity of the Bleck See. This is of vitel importence, since in most ceses, the spawning biomass of tha fish species concerned have less effect on the recruitment then hes the environment, especially after eutrophication and the invasion of a number of new species,

most importantly, the ctenophore *Mnemiopsis*. It is not unlikely that new species experience a period of adaptation to the current environmental conditions, such that after some years, they do not cause population outbursts that could further disrupt the balance that the Black Sea ecosystem is striving for.

BLACK SEA WHITING, *MERLANGIUS MERLANGUS EUXINUS* NORDMANN

Tha taxonomic position of the Black Sae whiting like thet of e great numbar of Black See fish spacias is rathar complicated, and is still a controversial question. According to Svetovidov (1935) the Black See whiting (*Odontodadus merlangus euxinus*) is ralatad to ganus *Odontogadus*, subfamily Gadinae, family Gadidee, order Gadiformes end rapresant subspecies of *Odontogadus merlangus merlangus*. The latter is distributed along the Europaen coest (from Murmensk to Gibreltar) and in the Mediterranean. The genus neme Odontogedus is givan by Gill (1863). *Odontogadus merlangus merlangus* was described by Linnaeus (1758) as *Gadus merlangus*. Subsequently Cuvier (1817) datachad this specias from tha genus Gadus, giving it the nama Merlangius merlengus. The Bleck Saa whiting was dascribed for the first time by Nordmenn (1830) es *Gadus euxinus*. Soma rasaarchars consider tha Black Sea and Atlantic whiting es tha sama fish spacies (Steindechner and D'Ancone - aftar Svetovidov, 1935), others as two species (Svatovidov). On the basis of morphometric, biological (Prodanov, 1983) and electrophoretic investigations (Dobrovolov, Dobrovolove and Prodanov, 1984) concludad thet both types of whiting ere separate species end gava them the following nemes: *Merlangius merlangus* (Atlentic whiting) and *Merlangius euxinus* (Black Sea whiting). In the FAO Yearbook of Fishery Statistics, the Black Saa whiting was presented undar tha nama *Odontogadus merlangus euxinus* up to 1973, latar on as *Merlangius merlangus;* i.e. initially it was considared e subspacies, but subsequently as identicel to the Atlentic whiting. However, it is difficult to explain why whiting from tha aastern Black Saa heva a growth rata quite diffarant from that in tha wastern half of tha besin. In terms of growth end lifa span, the fish inhabiting the aastarn part of the Bleck See hava an intermedieta position betwaen the two mentioned types. Therefore, essessments of the stock dynamics of tha Black Saa whiting wera cerriad out separetely for the two perts of tha Bleck Sea.

In the eastern pert of tha besin the whiting is subject to a specialised fishery, while in its western part it is fished primarily as a by-catch in trawl sprat catchas and by trap nats. This last consideration reduces the precision of fishary statistics for whiting catchas in tha wastarn Black Saa (Prodanov, 1984). For this reason it has always been considered that in the wast the species is lightly exploited. Domashenko and Serobaba (1990) reported that in 1980-1981 the coefficient of exploitetion had values around 0.20, i.e. considerably lowar than tha optimum value of 0.45 (Domashanko *et al.*, 1985). In contrast, Prodanov (1990) claimad thet the coafficient of exploitetion had to be around 0.35.

According to Shlyekhov (1982) tha sherp fluctuations in the whiting biomass wera causad by the different yeer class strengths and also changes in its naturel mortality.

Kirsonove end Lushnikova (1990) established thet the Bleck Sea spiny dogfish consume ennually an avarega of 70 000 tonnes of whiting. Whiting is also a basic food componant in tha diat of the turbot, the thornback rey end the stingrey. From the ebove it is evidant thet the rate of neturel mortelity of the whiting is highly correlated with the abundance of predators. Tha most importent of these is at present the spiny dogfish, because it has no ennemies. Its reproduction being oviparous it is not directly effected by anvironmantel conditions and is not heavily exploitad (et leest from official fishery stetistics). Tabla **54** shows the whiting catches in the western and aastern parts of the basin.

Tabla **55** shows the age composition of whiting catches in the westarn part of the basin.

According to tha date presented, meen veluas of totel mortelity for fully represented age groups are as follows: 2 - 0.6592; 3 - 0.8063; 4 - 1.0241; 5 - 0.9767. Givan that tha maan value of M is in tha renga of 0.85-0.70 (Prodanov, 1984) we mey deduct that it has the following velues by aga groups: 1 - 0,70; 2 - 0.55; 3 - 0.70; 4 - 0.90; 5 - 0.90. The value mentionad for the oldest aga group may ba slightly high. Such en approech is not well eccepted by most researchers sinca using tha traditional VPA this would elweys lead to overestimetes of the biomesses for exploited fish species. The overastimation is aspecielly high for specias with a short life span and high netural mortelity such as most pelagic fish in the Black Sea.

TABLE 54. Whiting landings in the Black Sea by areas and countries (in tonnes) during the period 1967-1994

Years	West. part of the Black Sea						East. part Total	West. part Total	Grand Total
	Bulgaria		Romania	Former USSR		Turkey			
	FAI	*	FAI	FAI	*	**			
1967									2966.7
1968									4526.8
1968									4728.9
1970						124.7	8987.3		9112.0
1971	0.0	0.0	381.0	0.0	0.0	65.4	5889.3	381.0	6335.8
1972	0.0	0.0	416.0	0.0	0.0	41.4	5023.2	416.0	5480.6
1973	0.0	0.0	329.0	0.0	0.0	522.8	1734.9	329.0	2688.5
1974	0.0	0.0	1305.0	0.0	0.0	138.4	2510.0	1305.0	3953.3
1875	454.0	754.0	346.0	0.0	0.0	381.3	3438.7	1100.0	4818.0
1976	377.0	1715.1	541.0	22.0	107.4	158.3	4054.0	2383.5	6578.8
1977	218.0	2134.8	1495.0	0.0	800.0	875.0	4851.3	4429.6	10155.8
1978	407.0	2912.6	1345.0	583.0	3283.0	1284.9	20000.3	7640.6	28805.8
1979	71.0	2563.5	1205.0	11377.0	17877.0	778.0	20000.0	21645.5	42423.6
1980	30.0	3889.8	618.0	2720.0	5500.0	1043.0	5795.0	9791.8	16630.2
1981	1.0	2563.5	894.0	2530.0	6500.0	1918.0	2751.0	9957.5	14628.5
1982	0.0	2760.3	800.0	1514.0	8200.0	1751.0	2513.0	11750.3	18014.3
1983	0.0	1506.5	1080.0	2381.0	7800.0	4046.0	7661.0	10386.5	22082.5
1984	0.0	1710.7	1192.0	4759.0	10500.0	5856.0	5739.0	13402.7	24997.7
1985	0.0	1500.8	3138.0	2684.0	5000.0	4948.0	11088.0	9638.8	25874.8
1986	0.0	1118.2	1949.0	2660.0	4800.0	3140.0	14598.0	7967.2	25605.2
1987	0.0	1057.8	615.0	2764.0	4500.0	4798.0	22305.0	6172.6	33275.6
1988	0.0	885.9	1009.0	2223.0	4500.0	3008.0	25255.0	6394.5	34657.9
1989	0.0	744.5	2738.0	591.0	6000.0	4075.0	15208.0	9482.5	28765.5
1990	0.0	359.4	2653.0	322.0	8800.0	2634.0	13625.0	11812.4	28071.4
1991	0.0	246.2	59.0	24.0	2600.0	7842.0	11314.01	2905.2	21861.2
1992	0.0	482.8	1357.0	0.0	900.0	5178.8	3143.4	1739.6	21059.8
1993	0.0	619.8			500.0	2856.3	7143.7		
1994	0.0					4350.1	10849.9		

* - the expert assessments of the level of real whiting catches of Bulgaria and former USSR are according to Prodanov's and Shlyakhov's data, respectively;

** - the Turkish catches in the eastern part of the Black Sea are taken eastern of Sinop, while these in the western part - from around the Bosporus. According to Ozdamar's data, the length compositions of these catches in the pointed areas are similar. That is why they were summarized and related to the eastern part only.

According to tha above-mantioned distribution of natural mortality coefficients, the mean value of M is 0.69; i.a. very close to 0.70. On account of this, VPA was carriad out in saveral variants - the first two at M = const. = 0.70 end with F_{st} = 1/2 F_{st} of sprat; this latter since tha whiting from the western part of the Black See is caught meinly as a by-catch in tha trewl sprat fishery. The first variant was carried out in tha traditional manner and the second, by tuning the values of F_{st} through additional iteration procedures. The third and fourth variants were also performed with M = const. = 0.70, but hare the values of F_{st} ware sat equal to 1/5 of those for sprat, since there is no specielized fishery for whiting. 8esides, the older age groups inhabit more open ereas of the sea (at depths 40-50 to 90-110m) and the most intansive trawl sprat fishery is conductad during spring and summer at dapths 25-30 - 50-60m. This last variant was carried out in accordance with the ebove-mentioned velues of M by age groups, and also by tuning the values of F_{st}, initially adoptad as equal to those of sprat.

TABLE 55. Aga composition (x 10^6 specimans) of whiting cetches (in tons) in the western pert of the 8leck Saa

Yeers	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	C_N	C_W	W
1971	7.17	11.2	6.57	2.89	1.49	0.70	0.29	30.31	381.0	12.57
1972	5.85	14.57	6.31	2.74	1.40	0.69	0.30	31.86	416.0	13.06
1973	4.03	9.59	6.46	3.51	1.67	0.80	0.23	26.29	329.0	12.51
1974	6.91	32.69	19.33	15.10	6.90	3.30	1.20	85.43	1305.0	15.28
1975	18.68	21.84	16.41	8.09	5.51	2.88	1.20	74.61	1100.0	14.74
1978	30.10	58.82	34.60	19.66	7.40	6.01	2.27	158.66	2363.5	14.90
1977	7.30	116.10	108.83	48.19	16.12	2.59	3.78	302.91	4429.6	14.62
1978	26.73	134.70	192.50	85.02	26.61	3.89	0.91	470.36	75.46	16.03
1979	32.11	134.33	358.59	246.57	94.59	6.21	1.30	873.70	21645.5	24.77
1980	310.50	220.50	103.71	88.59	75.20	35.66	1.92	836.08	9791.8	11.71
1981	30.29	353.08	184.91	85.79	34.78	18.89	8.92	716.64	9957.5	13.89
1982	626.30	253.31	175.37	98.64	38.98	18.56	7.63	1218.79	11750.3	9.64
1983	113.35	360.48	132.33	86.27	45.68	14.77	6.09	758.97	10386.5	13.68
1984	172.24	303.03	259.97	112.21	48.83	19.12	2.78	918.18	13402.7	14.60
1985	160.08	232.72	133.52	104.75	39.84	15.78	6.86	693.55	9638.8	13.90
1986	105.08	225.82	110.03	54.24	36.94	10.34	9.70	552.15	7967.2	14.43
1987	59.38	205.71	101.04	39.92	19.47	18.58	3.25	447.35	6172.6	13.80
1988	82.96	204.58	83.12	46.28	14.45	5.12	10.25	446.76	6394.5	14.31
1989	215.86	260.63	105.55	46.33	24.91	6.12	2.34	661.74	9482.5	14.33
1990	755.43	157.25	129.97	30.56	14.01	10.36	2.86	1100.44	11812.4	10.73
1991	71.18	90.00	42.90	12.78	4.93	1.79	1.96	225.54	2905.2	12.88
1992	61.85	69.49	40.96	19.05	3.69	0.96	0.55	196.55	2739.6	13.94
1993	41.89	44.91	18.13	15.16	4.65	0.86	0.13	125.73	1718.8	13.67

C_N - catch in numbars (x 10^{-6} spacimens) ; C_W - catch in tonnas; W - mean weight (g)

Teble 56 and **Figure 20** present the results from the first variant of VPA.

From **Table 56** it is saan that the whiting biomass (B1+) in the western part of the basin during the period 1971-1993 has veried from 85.8 (1989), to 204.5 (1981) and to 209.0 (1983) thousand tonnes. This variation is due to the different abundance of individual year classes. The most abundent appeared to ba tha 1982 and 1980 yaer clessas - 15.708 x 10^9 and 14.160 x10^9 numbars of age groups 0+, respectively. The 1975, 1979 end 1978 year classas (13.262, 12.627 end 12.236 x 10^9, respectively) ware close to the ebove values, followed by the 1977, 1971 end 1990 year classes (10.428, 9.804 end 9.086 x 10^9 numbers, respectively). The other year classes were madiocre, and ranged within sizes 4.907 x 10^9 (1983) end 8.332 x 10^9 (1985). This fector dominated fluctuations in whiting biomass during the period 1971-1993.

TABLE 56. Whiting numbers (x 10^9 sp.) and biomass (x 10^3 tonnes) in the western part of the Black Sea during the period 1971-1994 (M = const. = 0.70; FS_{st} = $1/2F_{st}$ of sprat - I variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	A_{1+}
1971	9.804	3.430	1.173	3.512	0.133	0.074	0.038	197.3
1972	2.094	4.864	1.696	0.578	1.742	0.065	0.036	203.1
1973	2.228	1.036	2.405	0.838	0.285	0.864	0.032	162.7
1974	3.538	1.104	0.508	1.190	0.414	0.140	0.429	126.5
1975	13.262	1.752	0.526	0.239	0.580	0.201	0.067	85.6
1976	12.627	6.573	0.855	0.250	0.113	0.284	0.098	134.1
1977	10.482	6.250	3.223	0.401	0.111	0.051	0.137	174.4
1978	6.191	5.200	3.023	1.526	0.166	0.044	0.024	189.1
1979	12.236	3.056	2.489	1.369	0.699	0.064	0.019	174.2
1980	14.160	6.054	1.425	0.992	0.512	0.283	0.027	178.9
1981	7.272	6.818	2.854	0.636	0.432	0.203	0.116	204.5
1982	15.708	3.590	3.143	1.290	0.258	0.191	0.088	183.8
1983	4.907	7.370	1.609	1.440	0.573	0.101	0.082	209.0
1984	5.260	2.359	3.412	0.708	0.656	0.253	0.040	175.1
1985	8.332	2.494	0.964	1.516	0.275	0.292	0.113	141.3
1986	3.863	4.027	1.079	0.388	0.681	0.110	0.134	133.2
1987	2.250	1.846	1.845	0.460	0.156	0.313	0.047	107.4
1988	3.523	1.076	0.776	0.847	0.201	0.064	0.143	82.7
1989	5.865	1.692	0.396	0.329	0.389	0.090	0.028	65.8
1990	9.086	2.764	0.663	0.125	0.132	0.176	0.041	71.1
1991	4.783	3.994	1.264	0.241	0.042	0.056	0.080	93.4
1992	5.609	2.326	1.921	0.598	0.111	0.017	0.026	96.8
1993	5.091	2.743	1.107	0.926	0.284	0.053	0.008	104.4
1994		2.499	1.311	0.537	0.449	0.138	0.025	

The calculations ara acomplished by the traditional VPA without additional iterations of F_{st}.

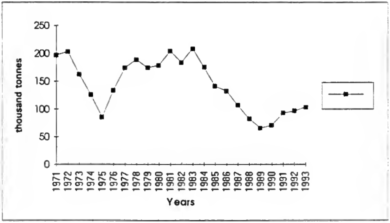


FIGURE 20. Whiting biomass (B_{1+} in thousand tonnes) in tha western part of the Black Sea (I variant)

TABLE 57. Fishing mortality coefficient of whiting in the western part of the Black Sea (by age groups) during the period 1971-1993 (l =0.70; F_{st} = 1/2 F_{st} of sprat - I variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+
1971	0.0010	0.0046	0.0078	0.0011	0.0157	0.0133	0.0108
1972	0.0039	0.0042	0.0052	0.0066	0.0011	0.0149	0.0116
1973	0.0025	0.0129	0.0037	0.0058	0.0082	0.0013	0.0101
1974	0.0027	0.0420	0.0542	0.0178	0.0234	0.0331	0.0039
1975	0.0020	0.0175	0.0443	0.0481	0.0133	0.0201	0.0250
1976	0.0030	0.0125	0.0577	0.1152	0.0949	0.0298	0.0328
1977	0.0010	0.0261	0.0479	0.1809	0.2235	0.0728	0.0390
1978	0.0060	0.0366	0.0922	0.0803	0.2481	0.1305	0.0550
1979	0.0037	0.0828	0.2204	0.0281	0.2057	0.1428	0.0987
1980	0.0309	0.0518	0.1080	0.1316	0.2251	0.1906	0.1007
1981	0.0058	0.0744	0.0939	0.2049	0.1179	0.1373	0.1123
1982	0.0568	0.1026	0.0804	0.1116	0.2329	01442	0.1278
1983	0.0326	0.0701	0.1206	0.0885	0.1166	0.2234	0.1084
1984	0.0465	01944	0.1112	0.2450	0.1086	0.1102	0.1004
1985	0.0270	0.1378	0.2110	0.1004	0.2216	0.0777	0.0880
1986	0.0385	0.0808	0.1515	0.2134	0.0781	0.1395	0.1052
1987	0.0373	01666	0.0788	0.1275	0.1890	0.0858	0.0998
1988	0.0332	0.3008	0.1597	0.0787	0.1045	0.1172	0.1047
1989	0.0524	0.2374	0.4488	0.2153	0.0928	0.0987	0.1215
1990	0.1219	0.0820	0.3117	04021	0.1587	0.0850	0.1027
1991	0.0209	0.0318	0.0482	0.0763	0.1778	0.0456	0.0345
1992	0.0154	0.0423	0.0300	0.0452	0.0472	0.0798	0.0293
1993	0.0115	0.0230	0.0230	0.0230	0.0230	0.0230	0.0230

Tables 58, 59 and **Figure 21** show the results of the second variant of VPA.

TABLE 58. Whiting numbers (x 10^9 sp.) and biomass (x 10^{-3} tons) in the western part of the Black Sea during the period 1971-1994 (M = const. = 0.70; $F_{at} = 1/2F_{at\ of\ sprat}$ - II variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	A1-6
1971	2.708	1.105	0.533	0.195	0.075	0.054	0.021	39.5
1972	1.096	1.340	0.541	0.260	0.095	0.036	0.026	44.8
1973	1.476	0.540	0.655	0.264	0.127	0.046	0.018	39.7
1974	2.734	0.730	0.262	0.321	0.129	0.062	0.022	36.8
1975	10.237	1.353	0.340	0.117	0.149	0.059	0.029	40.1
1976	10.210	5.071	0.657	0.158	0.052	0.070	0.027	87.3
1977	8.447	5.049	0.478	0.302	0.065	0.021	0.031	128.7
1978	4.561	4.189	2.427	1.155	0.117	0.021	0.009	147.2
1979	7.142	2.246	1.988	1.073	0.515	0.040	0.008	132.8
1980	9.165	3.524	1.023	0.743	0.366	0.192	0.016	118.9
1981	5.282	4.337	1.599	0.437	0.309	0.131	0.071	128.0
1982	10.005	2.602	1.912	0.667	0.159	0.129	0.052	113.6
1983	3.618	4.538	1.119	0.829	0.264	0.053	0.052	124.7
1984	3.250	1.718	2.006	0.465	0.353	0.100	0.016	103.2
1985	4.046	1.495	0.647	0.819	0.155	0.142	0.037	78.2
1986	2.583	1.899	0.584	0.231	0.335	0.050	0.060	66.4
1987	1.921	1.210	0.789	0.215	0.078	0.141	0.018	52.3
1988	2.406	0.913	0.461	0.323	0.080	0.026	0.057	41.3
1989	2.657	1.137	0.315	0.172	0.129	0.030	0.009	34.6
1990	4.092	1.171	0.389	0.086	0.054	0.047	0.011	31.2
1991	2.109	1.519	0.474	0.106	0.022	0.018	0.016	34.8
1992	3.247	0.999	0.693	0.206	0.044	0.008	0.007	36.6
1993	4.186	1.570	0.448	0.316	0.089	0.019	0.003	44.2
1994		2.050	0.749	0.210	0.146	0.041	0.009	

* Numbers and biomass of whiting after 5th iteration

It is sean from the above tebla that efter tha fifth iteration, the estimated whiting biomass is considerebly lower then thet obteined by treditional VPA. As was pointed out for shad end enchovy, the results mentioned were due to the fact that the second approach works on the assumption that values of F for the completely recruited age groups should be the same. This is why the estimetes of F by ege groups end the ebundence of their corresponding year clesses were respectively higher and lower with the second epproech. Thus for instence, the F velua for the 1982 yeer class was 0.0058 with tha first epproach, while tha seme velue in the second epproech is 0.0906, i.e. 15 times higher. Conversely, the ebundence of the year class mentioned according to the first menner of computetion wes 15.708 x 109 specimens, end by the second - 10.085 x 109 specimens of 0+ year old fish. Taken as a whole, the trends for the two approaches are rather similar, despite some differences in the assessments of ebundance for individual yaer clesses. To a certain extent, this reflects on the estimetes of the whiting biomess, which were significantly lower following the second epproach. Besidas, the maximum values for whiting biomess reached did not coincide in time. Thus for instance in the first verient the maximum biomess of 209.0 thousand tonnes wes involvad in 1983, but in the second epproech e peek of 147.2 thousand tonnes wes shown in 1978, i.e. its absoluta value is lower by about 30% and is shifted tamporelly by 5 years.

TABLE 59. Fishing mortelity rate of whiting (by ega groups) in the westarn part of the Black See during 1971-1993 (M = 0.70; F_{st} = 1/2 F_{st} of spret II verient)

Yaars	0+	1,1+	2,2+	3,3+	4,4+	5,5+	8,8+
1971	0.0037	0.0142	0.0173	0.0207	0.0278	0.0183	0.0192
1972	0.0075	0.0152	0.0183	0.0147	0.0207	0.0268	0.0161
1973	0.0038	0.0249	0.0138	0.0188	0.0184	0.0243	0.0183
1974	0.0035	0.0640	0.1077	0.0674	0.0771	0.0765	0.0770
1975	0.0025	0.0227	0.0892	0.1007	0.0528	0.0698	0.0600
1976	0.0041	0.0162	0.0757	0.1882	0.2157	0.1258	0.1214
1977	0.0012	0.0324	0.0628	0.2467	0.4119	0.1862	0.1854
1978	0.0082	0.0456	0.1160	0.1072	0.3693	02873	0.1567
1979	0.0083	0.0884	0.2837	0.3749	0.2893	0.2378	0.2538
1980	0.0481	0.0905	0.1505	0.1792	0.3286	0.2935	0.1834
1981	0.0080	0.1193	0.1735	0.3120	0.1686	0.2207	0.1898
1982	0.0908	0.1441	0.1353	0.2268	0.4054	0.2193	0.2241
1983	0.0444	0.1162	0.1777	0.1548	0.2703	0.4779	0.1772
1964	0.0762	0.2765	0.1962	0.3974	0.2110	0.3024	0.2679
1985	0.0564	0.2402	0.3306	0.1935	0.4281	0.1663	0.2947
1988	0.0580	0.1787	0.2978	0.3849	0.1647	0.3296	0.2522
1987	0.0438	0.2851	0.1938	0.2923	0.4137	0.1997	0.2847
1988	0.0490	0.3640	0.2835	0.2194	0.2848	0.3186	0.2802
1989	0.1190	0.3737	0.5984	0.4528	0.3072	0.3286	0.4205
1990	0.2909	0.2040	0.5970	0.6472	0.4293	0.3572	0.4519
1991	0.0479	0.0855	0.1333	0.1810	0.3571	0.1510	0.1806
1992	0.0268	0.1012	0.0854	0.1364	0.1230	0.1863	0.1066
1993	0.0140	0.0405	0.0577	0.0888	0.0748	0.0638	0.0579

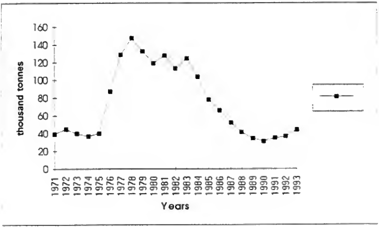


FIGURE 21. Whiting biomass (B_{1+} in thousend tonnes) in the western pert of the Bleck See (II variant)

Tables 60, 61 end **Figure 22** present the results from the third variant of VPA are presented.

Whiting biomass ranged betwaen 129.6 (1989) and 503.2 (1972) thousand tonnes. The common feetures of the variants considared is that in both of them the minimum biomess of whiting occurrad in 1989. In relation to the maximum it has to be noted thet it is shifted even eerlier to 1972 in the third varient. With regerd to the abundance of year classes the variations are identical with those existing in the first veriant, but they ere considerebly higher in absolute velues. This is related to the lower estimates of F_{st} used in the third verient.

In **Tebles 62, 63** and **Figure 23** the results from the fifth variant are shown where M values between age groups differ.

The estimates of year classes abundance in this variant were similer to those found in the first veriant, but the formar hed lower absolute values. The only difference is that with this approach the 1985 yeer class is stronger than the 1971 year class.

Teble 64 gives the finel result after the 6th iteretion in the first, third and fifth varients, and in **Figure 24** only the last two variants, since the differences between the first 4 variants are negligibla end cen herdly be grephically differentiated. From the figure it is seen thet the trends between tha 4 variants mentioned and the 5th (M values among age groups) were equal (after the 6th iteration), and differences were releted only to the ebsolute figures used during the period 1971-1993.

TABLE 60. Whiting numbers (x 10^9) and biomass (x 10^3 tons) in the western pert of the Black Sea during the period 1971-1994 (M = const. = 0.70; F_{st} = 1/5F_{st} of sprat - III variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	B_{1+}
1971	23.285	8.233	2.820	9.103	0.329	0.184	0.094	497.4
1972	4.379	11.558	4.076	1.396	4.518	0.162	0.091	503.6
1973	4.062	2.171	5.730	2.019	0.691	2.243	0.080	397.5
1974	6.196	2.014	1.071	2.841	1.000	0.342	1.113	300.1
1975	24.340	3.072	0.978	0.519	1.400	0.492	0.168	185.9
1976	20.988	12.074	1.510	0.474	0.252	0.692	0.242	263.5
1977	18.304	10.401	5.955	0.726	0.222	0.120	0.339	317.7
1978	10.052	9.084	5.085	2.882	0.328	0.099	0.058	338.0
1979	23.091	4.973	4.418	2.393	1.373	0.144	0.047	311.9
1980	26.985	11.444	2.377	1.948	1.019	0.617	0.067	342.8
1981	11.824	13.186	5.531	1.109	0.906	0.455	0.282	403.5
1982	29.327	5.851	6.305	2.619	0.492	0.426	0.213	358.6
1983	7.599	14.132	2.731	3.010	1.233	0.218	0.199	412.8
1984	9.138	3.695	6.769	1.265	1.435	0.581	0.098	344.1
1985	16.241	4.419	1.627	3.183	0.551	0.679	0.275	284.7
1986	6.491	7.955	2.035	0.717	1.508	0.246	0.326	274.1
1987	3.050	3.151	3.795	0.935	0.319	0.724	0.115	219.5
1988	6.117	1.473	1.423	1.815	0.437	0.145	0.346	166.4
1989	12.801	2.981	0.592	0.650	0.869	0.207	0.068	129.6
1990	20.317	6.208	1.301	0.222	0.291	0.415	0.099	155.4
1991	11.451	9.569	2.975	0.557	0.090	0.135	0.199	222.0
1992	13.811	5.637	4.690	1.448	0.268	0.041	0.066	235.3
1993	12.688	6.815	2.751	2.301	0.706	0.131	0.020	259.3
1994		6.272	3.353	1.354	1.132	0.347	0.064	271.7

* It is identical with variant I but the F_{st} value is equal to 1/5 of F_{st} instead of 1/2 F_{st} for sprat.

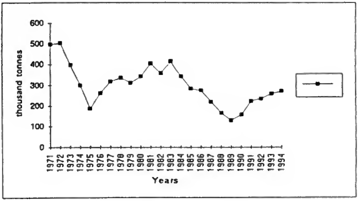


FIGURE 22. Whiting biomass (B_{1+} in thousand tonnes) in the western part of the Black Sea (III variant)

TABLE 61. Fishing mortality coefficient of whiting (by age groups) in the western part of the Black Sea during the period 1971-1993 (M = const. = 0.70; F_{st} = 1/5F_{st} of sprat III variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+
1971	0.0004	0.0019	0.0032	0.0004	0.0063	0.0053	0.0043
1972	0.0019	0.0018	0.0022	0.0027	0.0004	0.0059	0.0046
1973	0.0014	0.0062	0.0016	0.0024	0.0034	0.0005	0.0040
1974	0.0016	0.0228	0.0254	0.0074	0.0096	0.0135	0.0015
1975	0.0011	0.0099	0.0236	0.0219	0.0055	0.0082	0.0100
1976	0.0020	0.0068	0.0323	0.0592	0.0416	0.0121	0.0131
1977	0.0006	0.0156	0.0257	0.0962	0.1058	0.0304	0.0156
1978	0.0037	0.0208	00539	0.0418	0.1190	0.0559	0.0221
1979	0.0019	0.0382	0.1189	0.1532	0.1001	0.0614	0.0395
1980	0.0161	0.0271	0.0624	0.0651	0.1075	0.0834	0.0403
1981	0.0036	0.0379	0.0475	0.1130	0.0546	0.0593	0.0449
1982	0.0301	0.0619	0.0394	0.0536	0.1159	0.0622	0.0510
1983	0.0209	0.0360	0.0695	0.0406	0.0527	0.0986	0.0434
1984	0.0265	0.1202	0.0547	0.1306	0.0483	0.0467	0.0402
1985	0.0138	0.0757	0.1203	0.0467	0.1052	0.0328	0.0352
1986	0.0227	0.0402	0.0778	0.1105	0.0346	0.0599	0.0421
1987	0.0274	0.0946	0.0376	0.0610	0.0883	0.0363	0.0399
1988	0.0190	0.2117	0.0843	0.0360	0.0470	0.0503	0.0419
1989	0.0237	0.1286	0.2799	0.1038	0.0406	0.0419	0.0486
1990	0.0529	0.0358	0.1481	0.2094	0.0690	0.0353	0.0411
1991	0.0087	0.0132	0.0202	0.0323	0.0793	0.0186	0.0138
1992	0.0062	0.0173	0.0122	0.0184	0.0193	0.0330	0.0117
1993	0.0046	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092

TABLE 62. Whiting numbers (x 10^{-9}) and biomass (x 10^{-3} tonnes) in the western part of the Black Sea during the period 1971-1994 (M_{0+} = 0.70, M_1 = 0.70, M_2 = 0.55, M_3 = 0.70, M_4 = 0.90, M_5 = 0.90, M_6 = 0.90; F_{st} = F_{st} of sprat V variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	A_{1+}
1971	7.179	2.496	0.852	2.866	0.110	0.050	0.021	155.1
1972	1.831	3.560	1.232	0.487	1.421	0.044	0.020	157.8
1973	1.845	0.808	1.758	0.708	0.240	0.577	0.017	120.7
1974	2.948	0.914	0.394	1.009	0.348	0.098	0.234	94.7
1975	11.093	1.459	0.431	0.213	0.491	0.137	0.037	88.8
1976	10.831	5.496	0.710	0.236	0.100	0.196	0.054	108.4
1977	8.812	5.259	2.689	0.384	0.104	0.038	0.076	144.8
1978	5.321	4.373	2.531	1.470	0.158	0.033	0.013	185.1
1979	10.007	2.624	2.079	1.317	0.871	0.048	0.011	155.5
1980	11.571	4.947	1.211	0.933	0.486	0.216	0.016	153.1
1981	6.197	5.532	2.305	0.621	0.403	0.152	0.066	168.7
1982	12.951	3.058	2.505	1.192	0.250	0.143	0.050	154.3
1983	4.277	6.001	1.344	1.314	0.524	0.078	0.047	176.6
1984	4.445	2.046	2.732	0.877	0.593	0.185	0.023	147.1
1985	6.701	2.089	0.809	1.382	0.260	0.211	0.064	119.1
1988	3.239	3.217	0.878	0.368	0.815	0.081	0.076	109.3
1987	2.008	1.536	1.443	0.425	0.146	0.227	0.027	86.5
1988	2.713	0.956	0.622	0.757	0.184	0.047	0.081	68.2
1989	3.358	1.290	0.336	0.297	0.344	0.066	0.016	54.2
1990	4.789	1.519	0.464	0.117	0.118	0.125	0.023	46.8
1991	2.414	1.864	0.647	0.172	0.037	0.039	0.044	49.0
1992	2.876	1.150	0.864	0.341	0.077	0.012	0.015	48.9
1993	2.558	1.385	0.523	0.468	0.156	0.029	0.004	52.7
1994		1.242	0.657	0.288	0.222	0.061	0.011	53.6

TABLE 63. Fishing mortality coefficient of whiting (by age groups) in the western part of the Black Sea during the period 1971-1993 (M_{0+} = 0.70, M_1 = 0.70, M_2 = 0.55, M_3 = 0.70, M_4 = 0.90, M_5 = 0.90, M_6 = 0.90; F_{st} = F_{st} of sprat V variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+
1971	0.0014	0.0063	0.0101	0.0014	0.0207	0.0215	0.0216
1972	0.0050	0.0057	0.0067	0.0079	0.0015	0.0241	0.0232
1973	0.0030	0.0167	0.0048	0.0069	0.0106	0.0021	0.0202
1974	0.0033	0.0509	0.0658	0.0210	0.0305	0.0531	0.0078
1975	0.0023	0.0210	0.0506	0.0542	0.0172	0.0323	0.0500
1976	0.0039	0.0149	0.0653	0.1219	0.1179	0.0474	0.0655
1977	0.0012	0.0311	0.0539	0.1898	0.2623	0.1141	0.0779
1978	0.0070	0.0437	0.1036	0.0834	0.2888	0.1972	0.1103
1979	0.0045	0.0735	0.2508	0.2957	0.2357	0.2149	0.1973
1980	0.0379	0.0637	0.1174	0.1403	0.2613	0.2819	0.2013
1981	0.0068	0.0924	0.1096	0.2105	0.1388	0.2051	0.2246
1982	0.0693	0.1215	0.0950	0.1214	0.2640	0.2163	0.2551
1983	0.0375	0.0868	0.1361	0.0952	0.1402	0.3288	0.2166
1984	0.0552	0.2273	0.1312	0.2579	0.1320	0.1680	0.2008
1985	0.0337	0.1666	0.2385	0.1106	0.2591	0.1190	0.1759
1986	0.0460	0.1021	0.1763	0.2262	0.0949	0.2103	0.2105
1987	0.0419	0.2035	0.0950	0.1389	0.2226	0.1310	0.1996
1988	0.0433	0.3449	0.1890	0.0884	0.1259	0.1764	0.2093
1989	0.0931	0.3227	0.5088	0.2406	0.1153	0.1503	0.2430
1990	0.2438	0.1539	0.4417	0.4389	0.1992	0.1333	0.2053
1991	0.0418	0.0692	0.0898	0.1083	0.2196	0.0724	0.0690
1992	0.0303	0.0873	0.0635	0.0804	0.0753	0.1259	0.0585
1993	0.0230	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460

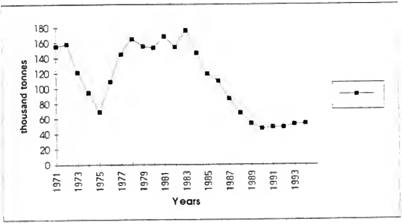


FIGURE 23. Whiting biomass (B_{1+} in thousand tonnes) in the western part of the Black Sea (V variant)

TABLE 64. VPA results after *ad hoc* tuning of the initial values of F_{st} for the oldest age group (6,6+)

Yaars	start *	atart **	start ***	I iteration *	I iteretion **	I iteretion ***	II itaration *	II itaration **	II itaration ***
1971	197.3	497.4	155.1	80.0	165.4	95.2	49.7	78.4	85.6
1972	203.1	503.6	157.8	78.7	154.1	95.9	53.0	78.8	90.4
1973	162.7	397.5	120.7	62.0	115.3	77.5	45.5	65.3	77.1
1974	126.5	300.4	94.7	52.2	91.0	65.0	41.5	57.0	67.4
1975	85.8	185.2	68.8	51.7	83.7	60.9	45.0	59.2	66.6
1976	134.1	263.5	108.4	108 0	155.1	123.3	98.0	123.3	135.5
1977	174.4	317.7	144.8	157.9	232.9	177.0	142.8	174.8	189.5
1978	189.1	338.0	165.1	185.3	278.9	215.3	185.1	203.3	227.9
1979	174.2	311.9	155.5	167.0	247.6	198.5	148.8	182.0	208.6
1980	178.9	342.8	153.1	153.7	233.2	182.3	134.4	165.5	188.6
1981	204.5	403.5	168.7	172.9	270.1	199.8	144.8	178.9	196.9
1982	183.8	358.6	154.3	153.5	237.1	176.3	127.5	156.2	189.2
1983	209.0	412.8	176.6	167.7	250.6	196.6	141.0	176.9	184.1
1984	175.1	344.1	147.1	138.6	199.7	159.5	118.4	148.4	148.4
1985	141.3	284.7	119.1	105.0	158.1	123.5	89.8	117.1	114.9
1986	133.3	274.1	109.3	90.8	140.6	101.4	78.8	109.5	95.8
1987	107.4	219.5	86.5	72.3	115.1	74.5	62.9	89.8	71.8
1988	82.7	166.4	68.2	57.4	92.9	57.2	48.9	71.2	56.0
1989	65.8	129.6	54.2	48.4	81.8	46.1	40.6	59.0	46.2
1990	71.1	155.4	48.8	48.3	90.6	41.7	38.4	59.3	42.3
1991	93.4	222.0	49.0	57.2	113.1	48.4	44.4	71.2	47.3
1992	98.8	235.3	48.9	59.2	115.6	48.3	48.3	73.4	49.1
1993	104.4	259.3	52.7	70.2	132.8	57.4	55.2	86.2	57.6

* - I varient ; ** - III variant; *** - V - variant

Table 64 - continued

Years	III ite-ration *	III ite-ration **	III ite-ration ***	IV ite-ration *	IV ite-ration **	IV ite-ration ***	V ite-ration *	V ite-ration **	V ite-ration ***
1971	43.2	56.9	93.9	41.1	47.8	101.6	39.5	42.4	103.2
1972	48.9	62.1	102.0	46.5	52.7	108.0	44.8	47.4	108.3
1973	43.1	53.6	87.8	41.0	45.7	91.5	39.7	41.6	91.2
1974	37.8	47.7	75.5	36.8	41.3	77.8	36.8	38.3	77.2
1975	41.0	42.6	72.1	40.1	43.9	72.9	40.1	41.5	72.2
1976	88.7	102.5	138.8	87.3	93.8	137.0	87.3	90.3	136.3
1977	130.5	146.7	190.7	128.7	136.9	187.6	128.7	132.6	187.0
1978	149.5	168.4	225.8	147.2	157.9	221.9	147.2	152.2	221.7
1979	134.9	151.6	205.5	132.8	142.7	202.3	132.8	137.3	202.2
1980	121.0	138.4	184.1	118.9	129.2	181.8	118.9	123.5	182.0
1981	130.1	154.5	191.8	128.0	141.0	190.8	128.0	133.6	191.3
1982	116.1	137.7	164.9	113.6	125.0	164.7	113.6	118.4	165.3
1983	126.1	154.6	181.0	124.7	138.2	181.5	124.7	130.2	182.2
1984	104.2	127.9	146.6	103.2	114.1	147.3	103.2	107.6	147.8
1985	79.1	99.1	114.1	78.2	87.4	114.8	78.2	81.9	115.2
1986	67.6	87.3	96.0	66.4	75.6	96.6	66.4	70.0	97.0
1987	53.5	69.4	72.4	52.3	59.8	72.9	62.3	55.2	73.1
1988	42.3	54.7	56.6	41.3	47.3	57.0	41.3	43.6	57.1
1989	35.5	45.3	46.8	34.6	39.3	47.1	34.6	36.3	47.2
1990	32.3	44.0	43.0	31.2	36.7	43.3	31.2	33.1	43.3
1991	36.3	51.4	48.0	34.8	41.8	48.3	34.8	36.9	48.3
1992	38.0	53.4	49.8	36.8	43.4	50.0	36.6	38.4	50.0
1993	45.9	63.4	58.1	44.2	51.9	58.3	44.2	46.0	58.4

* - results from VPA (I variant) after 5th iteration
** - results from VPA (III variant) after 5th iteration
*** - results from VPA (V variant) after 5th iteration

In **Table 65** the age composition of the whiting catches in the eastern part of the Black Sea is presented. These data were made available to us by V. Shlyakhov (YugNIRO, Ukraine). According to this author the whiting from the eastern part of the Black Sea reaches a length of 35 cm and age 8 years. In relation to size composition of the catches, the Turkish date are akin to those of the cited author, but differ radically in age structure.

TABLE 65. Age composition ($\times 10^6$) of whiting catches (in tonnes) in the eastern part of the Black Sea

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	7,7+	8,8+	CW	W
1971	21.06	15.18	25.14	42.13	26.40	5.34	3.09	1.82	0.28	5954.8	42.4
1972	5.24	15.02	30.26	34.93	22.82	5.24	1.75	0.82	0.35	5064.6	43.5
1973	8.79	21.12	39.70	16.14	4.26	0.55	0.10	0.00	0.00	2257.5	24.9
1974	5.15	5.67	24.39	30.87	8.06	0.30	0.08	0.08	0.00	2648.3	35.5
1975	24.08	15.95	57.98	36.90	6.70	0.71	0.14	0.00	0.00	3818.0	26.8
1976	47.86	25.50	62.83	44.16	3.70	0.55	0.19	0.00	0.00	4213.3	22.8
1977	35.61	54.61	89.98	52.55	6.26	1.20	0.48	0.00	0.00	5726.3	23.8
1978	44.88	89.77	370.12	191.31	35.32	2.94	0.74	0.74	0.00	21265.2	28.9
1979	2.65	7.94	92.64	242.19	78.76	13.68	3.09	1.76	0.44	20778.0	47.1
1980	79.93	18.55	26.86	41.50	38.73	8.63	0.43	0.43	0.65	6838.0	31.7
1981	40.57	47.92	34.97	31.13	9.62	9.44	0.87	0.35	0.00	4669.0	26.7
1982	16.27	23.81	69.61	26.67	11.45	2.26	0.30	0.15	0.15	4264.0	28.3
1983	24.51	32.92	166.68	90.00	20.66	8.76	5.60	0.70	0.35	11696.0	33.4
1984	0.16	0.49	15.87	53.12	42.43	39.35	6.34	3.56	0.62	11595.0	71.6
1985	31.55	6.87	6.66	18.25	63.11	61.83	22.11	3.22	1.07	16036.0	74.7
1986	10.06	19.89	26.28	20.57	45.26	70.40	28.80	6.40	0.92	17738.0	77.6
1987	2.07	31.55	186.71	110.17	97.24	64.14	19.66	4.07	1.62	27103.0	52.4
1988	51.39	154.16	263.07	186.28	115.62	23.89	6.62	1.30	0.60	28263.0	35.2
1989	35.02	105.07	179.51	126.96	78.81	16.96	3.83	1.55	0.10	19283.0	35.2
1990	21.10	12.26	89.36	148.93	87.25	8.76	1.75	0.00	0.00	16259.0	43.9
1991	418.01	844.13	257.62	64.81	32.40	1.60	1.60	0.00	0.00	18956.0	11.7
1992	186.93	218.22	368.33	101.95	22.11	6.13	1.89	0.00	0.00	18320.2	20.2
1993	54.30	81.56	104.23	129.15	36.93	5.05	0.65	0.49	0.00	10000.0	24.3
1994	65.60	203.18	90.48	48.96	70.45	12.18	1.48	0.13	0.09	15000.0	30.5

CN - total catches ($\times 10^6$); CW - total catches (in tonnes $\times 10^3$); W - mean weight values (g)

The differences between the weights at x age are still greater, namely:

Aga	Eastern part of Black Sea W (g)	Western part of Black Sea W (g)
0+	4.0	4.2
1	12.8	11.6
2	23.4	21.4
3	44.4	33.7
4	71.7	48.2
5	104.2	63.3
6	140.9	79.2
7	180.2	
8	222.0	

On tha basis of these data for the western part of the basin the perameters of von Bertalanffy's equation were esteblished:

W_{∞} = 285.5 g   k = 0.12715   to = - 2.31128

The pointed values do not differ significantly from those defined only on the basis of tha Bulgerian data (Prodanov, 1984):

W_{∞} = 231.9 g   k = 0.135   to = - 2.412

When Shlyakhov's data for whiting growth in weight by ages in the eastern part of the Black Sea were used in the same manner, a value of W_{∞} = 2270.0 g was obtained that is too high.

Teble 66 and **Teble 67** show tha results from VPA with tuning of the initial valuas of fishing mortality coefficient for the oldest age group (8 year olds). From **Teble 66** it is seen that whiting biomass in tha aastern part of tha Black Sea ranged from 73.0 (1990)/73.9 (1989) to 489.3 (1978) thousand tonnes. Tha fluctuations in tha eastern population biomass coincidad as a trand with those of the western population but the former had higher values when comparing their ebsolute values (on everega, two-fold). Thasa differancas wara dua mora to the heaviar weights usad for tha whiting than tha highar abundanca, both ralating to tha aastern part of tha Black Saa.

Figure 25 shows the VPA data for 0+ yaer old fish abundance and tha onas obtainad by trawl surveys carried out by YugNIRO (usually in May). It is seen from this Figure that the assessments of total 0+ year old fish abundanca by tha two mathods had a similar trand and did not diffar substantially in absoluta values. Relatively highar diffarances wara datectad for tha araas, primerily in 1982, since the estimates from trawl surveys showed that recruitment abundance in tha wastern and the eastern parts of tha basin was 5.3 and 14.1 x 10^9 of specimans respectively, ovarall 19.4 x 10^9 specimans and from VPA, 13.0 and 3.6, total 16.6 x 10^9 numbars of specimens. Despite the differences, the coincidence as a whole is quite significant, espacially for tha recruit abundance in the entire Black Saa, and showed that VPA results could be used further for analysing the ceuses of whiting recruitment veriations.

TABLE 66. Whiting numbers (x 10^{9}) and biomass (x 10^{3} tonnes) in the eastern part of the Black Sea during the period 1971-1994

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	7,7+	8,8+	Å1+
1971	6.572	0.377	2.101	0.228	0.078	0.068	0.036	0.013	0.002	84.7
1972	24.968	3.249	0.196	1.194	0.106	0.021	0.024	0.010	0.003	114.9
1973	5.406	12.395	1.772	0.091	0.697	0.037	0.005	0.007	0.002	260.6
1974	9.331	2.679	6.787	0.993	0.043	0.343	0.015	0.002	0.000	278.4
1975	9.436	4.630	1.466	3.898	0.578	0.016	0.139	0.005	0.000	330.2
1976	30.744	4.669	2.529	0.802	2.335	0.283	0.006	0.046	0.000	360.7
1977	12.306	15.234	2.544	1.412	0.453	1.157	0.115	0.002	0.000	486.7
1978	7.520	6.086	8.321	1.400	0.816	0.221	0.470	0.038	0.000	489.3
1979	13.058	3.703	3.275	4.524	0.703	0.381	0.088	0.156	0.010	454.6
1980	9.796	6.408	2.027	1.820	2.558	0.297	0.147	0.028	0.042	460.4
1981	8.304	4.809	3.544	1.149	1.072	1.243	0.115	0.049	0.000	426.9
1982	3.607	4.096	2.604	2.019	0.673	0.526	0.500	0.038	0.013	386.2
1983	2.992	1.780	2.230	1.450	1.204	0.326	0.212	0.166	0.010	321.9
1984	3.434	1.469	0.953	1.162	0.810	0.584	0.127	0.068	0.045	251.8
1985	4.272	1.705	0.805	0.537	0.664	0.373	0.213	0.039	0.017	192.0
1986	4.356	2.300	0.930	0.460	0.312	0.287	0114	0.059	0.009	149.6
1987	3.297	2.156	1.138	0.517	0.263	0.124	0.075	0.023	0.013	126.5
1988	2.430	1.636	1.160	0.517	0.230	0.066	0.014	0.015	0.005	100.3
1989	4.342	1.171	0.786	0.475	0.174	0.039	0.012	0.002	0.004	73.9
1990	8.969	2.132	0.567	0.321	0.192	0.035	0.006	0.000	0.000	73.0
1991	3.956	4.439	1.161	0.261	0.083	0.038	0.009	0.000	0.000	106.8
1992	4.343	1.678	1.829	0.479	0.109	0.020	0.014	0.000	0.000	97.5
1993	12.975	2.028	0.763	0.782	0.213	0.039	0.005	0.004	0.000	99.2
1994	6.081	6.377	1.046	0.356	0.369	0.079	0.013	0.001	0.001	158.7
1995		2.995	3.368	0.540	0.183	0.139	0.025	0.003	+	

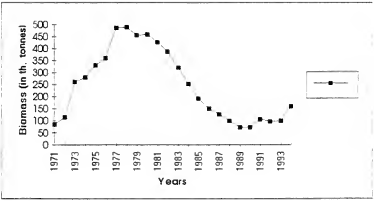


FIGURE 24. Whiting biomass (B1+ in thousand tonnes) in the eastern part of the Black Sea (data according to Table 66)

TABLE 67. Fishing mortality coefficients (by age groups) in the eastern part of the Black Sea (M = const. = 0.70)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	7,7+	8,8+
1971	0.0045	0.0548	0.0157	0.2648	0.6088	0.1252	0.1514	0.2722	0.2413
1972	0.0003	0.0062	0.2216	0.0378	0.3475	0.4555	0.1241	0.1518	0.2501
1973	0.0023	0.0023	0.0295	0.2637	0.0085	0.0227	0.0308	0.0788	0.0788
1974	0.0008	0.0028	0.0047	0.0403	0.2989	0.0013	0.0090	0.0845	0.0000
1975	0.0036	0.0046	0.0527	0.0121	0.0162	0.0707	0.0017	0.0372	0.0000
1976	0.0022	0.0073	0.0328	0.0723	0.0022	0.0030	0.0538	0.0273	0.0000
1977	0.0040	0.0048	0.0470	0.0483	0.0194	0.0016	0.0069	0.0289	0.0000
1978	0.0083	0.0198	0.0594	0.1891	0.0618	0.0204	0.0026	0.0354	0.0000
1979	0.0003	0.0029	0.0374	0.0702	0.1830	0.0558	0.0594	0.0203	0.0815
1980	0.0114	0.0038	0.0174	0.0294	0.0213	0.0450	0.0048	0.0282	0.0282
1981	0.0068	0.0133	0.0129	0.0350	0.0125	0.0116	0.0125	0.0130	0.0000
1982	0.0063	0.0078	0.0353	0.0169	0.0239	0.0065	0.0010	0.0071	0.0207
1983	0.0114	0.0249	0.1017	0.0818	0.0241	0.0414	0.0443	0.0076	0.0625
1984	0.0001	0.0004	0.0219	0.0597	0.0752	0.1070	0.0712	0.0978	0.0661
1985	0.0103	0.0054	0.0108	0.0440	0.1405	0.2823	0.1842	0.1549	0.1199
1986	0.0032	0.0127	0.0373	0.0584	0.2220	0.4472	0.5054	0.2102	0.1923
1987	0.0009	0.0198	0.2371	0.3110	0.6818	1.2627	0.5362	0.1721	0.6260
1988	0.0298	0.1330	0.3431	0.5909	1.0748	0.7769	0.9150	0.0375	0.7023
1989	0.0113	0.1262	0.3461	0.4065	0.9125	0.9581	0.6587	0.8587	0.6587
1990	0.0033	0.0077	0.2269	0.8440	0.9179	0.4625	0.5985	0.0000	0.0000
1991	0.1574	0.2869	0.3345	0.3729	0.7272	0.0656	0.3400	0.0000	0.0000
1992	0.0615	0.1879	0.2990	0.3104	0.3247	0.5864	0.2365	0.0000	0.0000
1993	0.0058	0.0548	0.1936	0.2329	0.2709	0.2147	0.2821	0.2536	0.0000
1994	0.0150	0.0430	0.1177	0.1865	0.2960	0.2543	0.2070	0.2172	0.2172

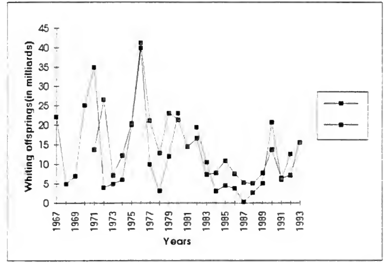


FIGURE 25. Number of whiting offsprings (x 10^9) in the Black Sea during the period 1967-1993 (1-ichthyoplankton surveys; 2- VPA)

BLACK SEA TURBOT, *PSETTA MAEOTICA* PALLAS

Commercially the Black Sea turbot is one of the most valuable species in the basin, and currently is fished with gillnets and bottom trawls even though, at present, the latter gear is prohibited.

In Bulgaria a minimal mesh size (180 mm) has been established for gillnets, and in 1989-1993 the turbot fishery was closed with a view to promoting the recovery of the stock along the Bulgarian coast. Actually the ban is valid only for the spawning season (May-June).

Prior to the prohibition of bottom trawling the Turkish fishery was carried out with this gear, but with a mesh size of 200 mm.

Table 68 shows turbot landings by countries during the period 1950-1992. During the years 1964-1992 Turkey had the largest landings, with a mean of 1990.1 tonnes that comprised 71.26% the mean total landing of 2793.1 tonnes. The next in size were the catches of the former USSR (531.7 tonnes or 19.04%), while those of Bulgaria and Romania were considerably lower, 196.9 tonnes (7.05%) and 74.0 tonnes (2.65%), respectively.

The big landings of Turkey are determined not only by the intensive fishery of this country along its own coast but also off the coasts of other Black Sea countries (**Table 69**).

Without indicating the fishing areas, apparently Turkish catches (following Turkish fishery statistics the landings taken west of Sinop refer to the western part of the basin), were greater in the western part of the Black Sea than in the eastern part, and totalled 1216.1 tonnes (60.83%) and 783.0 tonnes (39.17%), respectively. According to Ivanov and Karapetkova (1979) and Ivanov and Beverton (1985), the fishing mortality of the exploited stock in Bulgarian waters was around 0.57 but mainly as a result of the Turkish fishery.

TABLE 68. Turbot landings in the Black Sea (in tonnes) during the period 1950-1992

Year	Bulgaria	Romania	former USSR	Turkey	Total	Year	Bulgaria	Romania	former USSR	Turkey	Total
1950	195.3		2600.0			1972	175.1	70.0	680.0	2124.3	3049 4
1951	180.0	156 0	2980.0			1973	248.5	118.0	530.0	2808.1	3704.6
1952	96.9	195.0	2420.0			1974	311.5	29.0	400.0	955.9	1696.4
1953	103 0	470.0	1940.0			1975	203.3	16.0	300.0	753.6	1272.9
1954	255.1	678.0	2000.0			1976	217.2	36.0	204.0	1126.3	1583.5
1965	198.9	383.0	1430.0			1977	63.1	15.0	98.0	1837.8	2011.7
1956	234.0	402.0	1500.0			1978	121.3	11.0	120.0	1907.4	2159.7
1957	458.4	189.0	740.0			1979	69.9	7.0	120.0	5250.3	5447.2
1958	368.6	80.0	940.0			1980	88.8	9.0	120.0	2625.0	2842.8
1959	247.5	275.0	1230.0			1981	9.5	2.0	120.0	3144 0	3275.5
1960	215.8	214.0	960.0			1982	9 4	2.0	110.0	4541.0	4662.4
1961	174.3	164.0	1200.0			1983	7.5	3.0	80.0	5216.0	5306.5
1962	431.7	182.0	1500.0			1984	20.8	4.0	50.0	2777.0	2851.8
1963	435.3	317.0	1600.0			1985	50.9	11.0	60.0	405.0	526.9
1984	460.2	393 0	1400.0	1521.8	3775.0	1986	12 4	7.0	10.0	399.0	428 4
1965	324.9	247.0	1300.0	1428 7	3298.6	1987	3.4	1.0	10 0	835.0	849.4
1966	425 6	134.0	1400.0	1331.5	3291.1	1988	3.6	2.0	0.0	1110.0	1116.6
1967	312.3	62.0	900.0	1528.6	2802.9	1989	0.9	0.0	0.0	1449.0	1449.9
1968	304 3	92.0	900.0	1679.7	2994.0	1990	0.1	0.0	0.0	1383.0	1383.1
1969	200.2	112 0	700.0	2128.6	3140.8	1991	0.1*	2 0	0.0	915.0	917.1
1970	267 9	124.0	700.0	4181.5	5273.4	1992	0.1*	1.0	25.0	418.0	444.1
1971	222.1	43.0	840.0	1946.6	3051.6						
Average							196.9	74.0	531.7	1990.5	2793.1
%							7.05	2 65	19 04	71 26	100.00

TABLE 69. Turkish catches of turbot by regions (in tonnes)

Years	Eastern part of the Black Sea	Western part of the Black Sea	Total
1972	1690.2	434.1	2124.3
1973	298.7	2509.4	2808.1
1974	532.8	423.1	955.9
1975	161.6	592.0	753.6
1976	251.6	874.7	1126.3
1977	213.9	1623.7	1837.6
1978	711.1	1196.3	1907.4
1979	3026.7	2223.6	5250.0
1980	1211.0	1414.0	2625.0
1981	1396.0	1748.0	3144.0
1982	903.0	3638.0	4541.0
1983	1365.0	3851.0	5216.0
1984	1202.0	1575.0	2777.0
1985	263.0	142.0	405.0
1986	228.0	171.0	399.0
1987	477.0	358.0	835.0
1988	1001.0	448.0	1449.0
1989	610.0	500.0	1110.0
1990	475.0	908.0	1383.0
1991	315.0	600.0	915.0
1992	110.0	308.0	418.8
Average	783.0	1216.1	1999.1
%	39.17	60.83	100.00

The problem of determining the turbot age composition is rather complicated. Following the mentioned authors the latter was made of 2-10 year old fish, and rarely included 11-12 year old fish. After Russian and Ukrainian data the age composition consists of 2-15 year old fish; rarely 16-17 year old ones. This was presumably due to different ageing interpretations pointed out by Ivanov and Beverton (1985). This further reflected on some population parameters, such as growth rate, natural mortality, etc. Thus for instance, Ivanov and Beverton (1985) obtained the following values for the parameters in von Bertalanffy's equation: $W_\infty = 13765.1$ g , k = 0.125 and n = 3.116.

According to Ukrainian data for length at age and weight at age the above-mentioned parameters were estimated:

L_∞	= 77.1 cm	W_∞	= 17793.8 g
k	= 0.130	k	= 0.051
t_o	= -0.881	t_o	= -2.843
		n	= 1.921

Following Ivenov and Beverton (1985) the values of M by age groups ware:

Age	2	3	4	5	6	7	8	9	10	11	12	13
M_t	0.25	0.20	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60

On the basis of this date the authors' mean value of M was 0.19 (M/k = 1.5).

Efimov *et al.* (1986) geve meen velues of M for meles end females: 0.103 end 0.138 respectively. In the sema peper they used averaga values of M = 0.100 and F_{ST} = 0.200 when performing VPA. Similar analysis was conducted by Ivenov end Beverton (1985) who used values of 0.190 end 0.500 respectively for the coafficients in consideration.

Popova showed that along the former USSR coest, the total biomess during 1950-1963 ranged from 10 300 tonnes (1958) to 15 800 tonnes (1954). Following Ivanov and Beverton, the biomass (B2+) of turbot along the Bulgarian Black Sea coast varied between 400 tonnes (1979) and 1710 tonnes (1963). Effimov *et al.* believed that for 1974-1984 it averaged to 17 000 tonnes (in former USSR waters). According to Acare (1985) who used Fox's production model, the biomass of turbot in the entire Black Sea wes about 26 000 tonnes (11 000 tonnes in the eastern and 15 000 tonnes in the western parts).

As already noted for the Russian sturgeon, the accuracy of biomess essessments depends to a great extent on the reliability of cetch magnitude. This concerns also turbot sinca sizeable emounts of landings are lacking from the fishery statistics. One can find support for this assertion in the Ukrainian deta for turbot catches taken during the sprat fishery. This letter uses trewls with mesh size 6 mm, so that immature turbot ere ceught as well. Following this date the meen turbot number in April-June, season during which the sprat fishery is the most intensive, is 5.5 specimens per trawl haul of 160 minute duration . Similar is the cese with Bulgarian and Romanian turbot catches. For instance during the trawl survey in September 1979 designed to establish the whiting distribution end biomass by depth, turbot numbers in cetches of control trawl hauls with e duration of 60 minutes, variad from 4-5 to 8-9 specimens. Having in mind that during 1978-1989 totel hours trawling for sprat approached and even exceeded 100 000 hours annually, it is not difficult to conclude that turbot landings recorded in fishery statistics ere much below reel catches. After the turbot fishery was halted (except for the Turkish fishery) its biomass showed signs of recovery. As a result, positive changes in turbot population structure took place that is supported by the Ukrainian data from YugNIRO:

Relationships between recruitment and spawning stock (in %) during 1980-1985 and 1989-1993

Periods	Racruitment (up to 45 cm)	Spawning stock (over 45 cm)
1980-1985	43.73	56.27
1989-1993	31.48	68.52

The YugNIRO date have to be assessed cerefully because in the lettar years juvenile cetches increased excessively end this may be tha reel cause for the indiceted changes in the relation between recruitment and parent stock.

Teble 70 shows the proportionel age composition of totel turbot catches during 1970-1988.

TABLE 70. Age composition of the turbot catches (x 10^3) and mean weight (W; kg) during the period 1970-1988

Year	2+	3+	4+	5+	6+	7+	8+	9+	10+
1970	94 921	462.441	224.711	706.313	406.052	306 826	109.558	49.936	14.529
1971	3 256	86.051	779.262	360.454	338.448	256 630	75.647	30.331	10.589
1972	2.815	109.343	74.783	303.940	314.250	263.336	108.762	42.401	16.409
1973	4.926	68.381	90.040	401 258	344.068	302.546	112.531	49.626	26.318
1974	3.342	8.920	14.118	71.015	164.262	162.345	57.732	35.460	17.073
1975	0 286	15.219	41.674	198.185	135.558	86.844	26.510	9.851	3.265
1976	38.796	121.633	49.187	145.583	130.540	90 853	26.821	17.814	9.402
1977	28.938	68.088	32.032	104.841	133.082	126.737	42.091	35.205	18.647
1978	31.278	89.925	70.004	273.314	187.205	138.891	42.635	26.810	14.429
1979	5 135	212 865	152.254	583 676	476 630	362.663	111.958	74.229	33.598
1980	18 629	110.325	60.000	236.010	281.131	214.600	71.735	37.017	14.516
1981	27 783	115.374	36.996	116.115	208 813	255 314	139 355	78.232	35.533
1982	0.100	180.744	108 300	314 743	267.140	268 608	119 803	110.380	57.882
1983	0.100	234.916	146.595	558.273	315.725	285.921	115 338	105.161	50.763
1984	0 100	87.748	80 728	74.586	122 847	131 622	107.930	74.586	20.182
1985	0 100	1.400	4.061	7 841	15.262	27.444	13.022	21.983	15 262
1986	0 100	0.100	0.400	8.819	10.322	21.044	0.401	4.610	9.821
1987	0.100	2.024	14 165	21.501	81.449	23.777	23 271	14.671	29.342
1988	0 100	0.100	0.400	34.493	52.206	43.195	67.433	15.227	29.521

TABLE 70 - continued

Year	11+	12+	13+	14+	15+	16+	17+	C_N	W
1970	10.762	13.129	5.704	3.013	4.735	2.475	0.000	2415.108	2.184
1971	9.243	3 141	1 076	1.346	1 705	0.808	0.000	1255.992	2.430
1972	14.231	12.488	2.614	1.743	0.581	0.000	0.000	1267 696	2.405
1973	17.751	18 600	4.476	2.701	1.466	0.463	0.000	1445.151	2.563
1974	13 626	16.964	5.855	3.064	5.472	1.861	0.000	581.109	2.919
1975	2.933	2.214	1.384	1.328	1.328	1.107	0.000	527 686	2.412
1976	8.610	11.876	5.641	4.849	6.037	1.781	0.099	669 522	2.365
1977	14.701	24.373	10.136	5.493	10.368	4.875	3.250	662.857	3.035
1978	11.636	9.961	2.793	2.700	2.700	0.465	0.093	904 839	2.387
1979	27.459	35.161	14.623	11.051	22.213	8.595	2.121	2134.231	2.552
1980	9.920	21.654	10.161	5.202	9.557	4.476	0.121	1105.530	2.573
1981	27.345	31.293	11.406	7.019	11.113	3.948	0.146	1105.785	2.962
1982	46.746	55.802	21.048	16.276	34.509	12.237	0.857	1615.175	2.887
1983	42.888	54.519	21.565	13.448	29.319	10.661	0.121	1985.313	2.673
1984	21.937	50.894	25.447	56.159	20.182	2.632	0.000	877.580	3.250
1985	12.042	7.841	6.301	3.220	2.940	1.400	0.000	140.119	3.763
1986	5.211	5.211	12.226	16.034	3.608	2 906	0.000	100.813	4.275
1987	7.841	7.588	7.588	9.359	8.347	2.024	0.000	253.040	3.358
1988	19.888	23.306	9.322	9.322	4.972	1.864	0.000	311.349	3.590

The indicated age structure is defined on the besis of tha age composition of catches by all Black Sea countries. For Bulgarian and Romanien catches since 1979, the age composition of former USSR was used. Tha latter wes elso applied to Turkish catches when data for size composition were not available. The results of VPA with tuning are presented in **Tables 71, 72** and **Figura 26**.

From the given date it is seen thet the turbot biomass (B2+) in tha Black Saa during 1970-1988 ranged between 6 100 tonnes (1988) end 25 800 tonnas (1979).

According to Ivanov end Beverton (1985) the turbot biomass (B2+) along the Bulgarien Black Sea coest during 1970-1979 variad from 1 210 tonnes (1973) to 450 tonnas (1978). Following our estimates, tha renge was 18 700 and 25 800 tonnas, respectivaly (for the entira Black Sae).

TABLE 71. Number (x 10^6) and biomass (last column: tonnes x 10^3) of turbot in the Black Sea during 1970-1988

Years	2	3	4	5	6	7	8	9	10
1970	3.168	2.688	1.907	1.839	1.090	0.585	0.310	0.175	0.160
1971	1.853	2.384	1.784	1.433	0.995	0.622	0.258	0.188	0.115
1972	2.381	1.441	1.874	1.464	0.995	0.598	0.345	0.172	0.146
1973	2.019	1.852	1.081	1.544	1.037	0.584	0.313	0.219	0.119
1974	2.585	1.568	1.454	0.847	1.016	0.631	0.262	0.188	0.155
1975	3.260	2.010	1.276	1.239	0.699	0.785	0.442	0.193	0.140
1976	3.470	2.539	1.632	1.059	0.933	0.518	0.662	0.395	0.169
1977	2.696	2.668	1.969	1.359	0.820	0.740	0.404	0.605	0.349
1978	2.638	2.074	2.123	1.665	1.130	0.633	0.580	0.344	0.262
1979	2.379	2.027	1.617	1.762	1.247	0.869	0.467	0.510	0.293
1980	2.442	1.848	1.468	1.251	1.042	0.699	0.473	0.335	0.402
1981	1.011	1.885	1.413	1.208	0.909	0.696	0.456	0.380	0.275
1982	1.272	0.763	1.439	1.182	0.983	0.641	0.414	0.298	0.277
1983	0.615	0.990	0.462	1.138	0.771	0.655	0.349	0.277	0.171
1984	0.454	0.479	0.600	0.263	0.502	0.412	0.345	0.219	0.156
1985	0.329	0.354	0.313	0.441	0.167	0.348	0.264	0.223	0.132
1986	0.012	0.256	0.288	0.266	0.392	0.140	0.304	0.239	0.185
1987	0.002	0.009	0.209	0.248	0.232	0.354	0.113	0.289	0.217
1988	0.010	0.001	0.006	0.167	0.204	0.137	0.313	0.085	0.254

Table 71 - continued

Years	11	12	13	14	15	16	17	B_{2-17}
1970	0.050	0.052	0.015	0.016	0.012	0.009	0.000	21.8
1971	0.131	0.033	0.031	0.007	0.009	0.005	0.000	18.9
1972	0.094	0.104	0.024	0.023	0.004	0.000	0.000	18.7
1973	0.116	0.068	0.074	0.017	0.016	0.002	0.000	18.1
1974	0.082	0.084	0.039	0.054	0.010	0.010	0.000	17.4
1975	0.124	0.068	0.060	0.025	0.037	0.008	0.000	19.5
1976	0.124	0.104	0.049	0.049	0.017	0.029	0.001	22.5
1977	0.144	0.099	0.029	0.031	0.029	0.002	0.015	24.4
1978	0.298	0.170	0.069	0.049	0.018	0.010	0.001	24.4
1979	0.223	0.246	0.081	0.049	0.034	0.011	0.006	25.8
1980	0.233	0.167	0.170	0.051	0.023	0.006	0.001	23.1
1981	0.350	0.191	0.117	0.123	0.033	0.008	0.001	21.7
1982	0.215	0.276	0.129	0.081	0.080	0.010	0.002	20.0
1983	0.196	0.142	0.176	0.082	0.046	0.032	0.000	15.9
1984	0.106	0.129	0.068	0.118	0.049	0.009	0.000	10.7
1985	0.122	0.071	0.060	0.030	0.040	0.018	0.060	8.0
1986	0.106	0.034	0.051	0.041	0.029	0.025	0.000	7.5
1987	0.158	0.080	0.072	0.029	0.017	0.011	0.000	7.0
1988	0.166	0.129	0.060	0.049	0.010	0.008	0.000	6.1

TABLE 72. Fishing mortality rate of turbot in the 8lack Sea during 1970-1988

Year	2	3	4	5	6	7	8	9	10
1970	0.0344	0.2097	0.1355	0.5141	0.4869	0.7683	0.4486	0.3492	0.1001
1971	0.0020	0.0406	0.0477	0.3060	0.4339	0.5490	0.3569	0.1826	0.1019
1972	0.0013	0.0873	0.0439	0.2455	0.4166	0.5986	0.3945	0.2954	0.1259
1973	0.0028	0.0416	0.0940	0.3180	0.4211	0.7536	0.4591	0.2677	0.2649
1974	0.0015	0.0063	0.0105	0.0922	0.1834	0.3057	0.2563	0.2175	0.1226
1975	0.0001	0.0084	0.0358	0.1838	0.2245	0.1204	0.0634	0.0546	0.0248
1976	0.0127	0.0543	0.0330	01558	0.1568	0.1980	0.0424	0.0480	0.0602
1977	0.0122	0.0286	0.0177	0.0845	0.1842	0.1930	0.1129	0.0861	0.0577
1976	0.0135	0.0490	0.0361	0.1891	0.1884	0.2545	0.0783	0.0845	0.0597
1979	0.0024	0.1229	0.1068	0.4259	0.5037	0.5575	0.2818	0.1635	0.1283
1980	0.0087	0.0681	0.0450	0.2206	0.3279	0.3773	01688	0.1218	0.0387
1981	0.0315	0.0699	0.0286	0.1065	0.2724	0.4705	0.3752	0.2399	0.1457
1982	0.0001	0.3012	0.0845	0.3271	0.3308	0.5598	0.3517	0.4835	0.2469
1983	0.0002	0.3017	0.4152	0.7180	0.5514	0.5922	0.4186	0.4995	0.3739
1984	0.0002	0.2251	0.1563	0.3531	0.2922	0.3955	0.3867	0.4343	0.1461
1985	0.0003	0.0044	0.0141	0.0188	0.0997	0.0843	0.0519	0.1081	0.1297
1986	0.0094	0.0004	0.0015	0.0355	0.0277	0.1670	0.0014	0.0203	0.0573
1987	0.0766	0.2721	0.0756	0.0956	0.4520	0.0714	0.2372	0.0541	0.1531
1988	0.0117	0.1051	0.0768	0.2439	0.3086	0.3901	0.2491	0.2063	0.1301

Table 72 - continued

Years	11	12	13	14	15	16	17
1970	0.2613	0.3240	0.5700	0.2440	0.6220	0.4263	0.0000
1971	0.0789	0.1097	0.0402	0.2739	0.2433	0.2433	0.0000
1972	0.1779	0.1412	0.1286	0.0913	0.2084	0.0000	0.0000
1973	0.1793	0.3594	0.0705	0.2057	0.1177	0.3107	0.0000
1974	0.1958	0.2524	0.1871	0.0680	0.9814	0.2603	0.0000
1975	0.0257	0.0428	0.0299	0.0635	0.0431	0.6793	0.0000
1976	0.0778	0.1339	0.1498	0.1498	0.5214	0.0895	0.1486
1977	0.1167	0.3164	0.1658	0.2311	0.6365	1.5017	0.3072
1978	0.0429	0.1046	0.0551	0.0654	0.1944	0.0607	0.1149
1979	0.1420	0.1712	0.2257	0.3459	1.3506	2.5855	0.5739
1980	0.0469	0.1545	0.0700	0.1263	0.6708	1.7364	0.3385
1981	0.0879	0.1982	0.1167	0.0681	0.4991	0.8415	0.2854
1982	0.2655	0.2513	0.2037	0.2630	0.6369	3.2263	0.5960
1983	0.2676	0.5443	0.1498	0.2103	1.2979	0.5113	0.5113
1984	0.2509	0.5635	0.5472	0.7788	0.6519	0.4382	0.0000
1985	0.1123	0.1295	0.1256	0.1303	0.0907	0.0988	0.0000
1986	0.0551	0.0633	0.3127	0.6251	0.2418	0.1462	0.0000
1987	0.0548	0.1031	0.1264	0.4590	0.8349	0.2518	0.0000
1988	0.1358	0.2213	0.1823	0.2445	0.5540	0.5540	0.2850

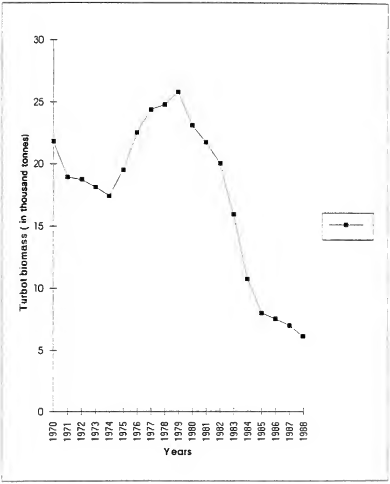


FIGURE 26. Turbot biomass in thousand tonnes in the Black Sea during the period 1970-1992 (VPA results with *ad hoc* tuning of F_{ST} values for the oldest age groups)

Tables 73 and **74** show the results from cohort analysis of the catch size composition during 1989-1990 and 1991-1992 (by Jones' method, 1981).

TABLE 73. Mean number (x 10^{3}) and biomass (in tonnes) of turbot during the periods 1989-1990

L	XL	CL	NL	F/Z	Z	F	NL*	BL
18	1.04888	0.2298	1624.522	0.0016	0.1402	0.0002	1056.345	507.0
23	1.05375	1.8617	1476.422	0.0125	0.1418	0.0018	1047.522	805.1
28	1.05969	8.1956	1327.884	0.0535	0.1479	0.0079	1035.319	1161.0
33	1.06712	4.1639	1174.760	0.0283	0.1441	0.0041	1020.393	1568.9
38	1.07666	67.4496	1027.721	0.3310	0.2093	0.0693	973.684	1962.9
43	1.08937	108.2086	823.929	0.4726	0.2655	0.1255	862.424	2204.5
48	1.10714	74.8374	594.956	0.4224	0.2424	0.1024	730.905	2307.8
53	1.13375	69.6787	417.784	0.4518	0.2554	0.1154	603.825	2306.2
58	1.17804	57.3478	263.568	0.4688	0.2636	0.1236	464.149	2107.8
63	1.26669	26.6205	141.239	0.3586	0.2182	0.0782	340.182	1810.8
68	1.53791	4.4192	67.011	0.1064	0.1567	0.0167	265.170	1634.5
73		10.6080	25.459	0.4167	0.2400	0.1000	106.08	749.3
Total		433.621						19125.8

TABLE 74. Mean number (x 10^{-3}) and biomass (in tonnes) of turbot during the periods 1991-1992

L	XL	CL	NL	F/Z	Z	F	NL*	BL
18	1.04888	5.1459	692.834	0.0757	0.1515	0.0115	448.679	215.4
23	1.05375	10.0358	624.859	0.1401	0.1628	0.0228	440.058	338.2
28	1.05969	13.7038	553.218	0.1864	0.1721	0.0321	427.098	478.9
33	1.06712	34.9275	479.714	0.3830	0.2269	0.0869	401.853	617.8
38	1.07666	34.9275	338.534	0.4071	0.2361	0.0961	363.409	732.6
43	1.08937	27.8028	302.733	0.3800	0.2258	0.0858	323.985	828.2
48	1.10714	38.1643	229.577	0.4972	0.2784	0.1384	275.695	870.5
53	1.13375	48.4170	152.823	0.6318	0.3802	0.2402	201.567	769.8
58	1.17804	23.5065	76.188	0.5700	0.3256	0.1856	126.667	575.2
63	1.26669	10.7578	34.945	0.4967	0.2782	0.1382	77.852	414.4
68	1.53791	5.0296	13.287	0.4598	0.2592	0.1192	42.205	260.4
73		0.9780	2.347			0.1000	9.780	69.1
Total		253.397						6170.5

The two assessments of turbot mean biomass during the periods 1989-1990 end 1991-1992 differ substantially. The estimatas of mean catches during the two periods, 1 416.5 end 680.6 tonnes respectively, are the major reason for these differences. The catches presented are probably strongly understeted especially during the second period, which hes an immediate effect on the essessments. This proves once more tha extreme importence of the real catch deta for tha reliability of VPA estimates.

In Teble 75 are shown the turbot biomass assessments obteined from control trawl hauls with a 24.6 metre bottom trawl a catchebility of 0.15 being assumed.

The essessments also differ essantially between each other during certain years and periods. Compering our estimetes with those of the mentioned authors we found that the former ara very closa to estimates of Acare (1985) end Effimov *et al.* (1986) . Therefore, the results from the VPA ware used for establishing the impact of tha factors influencing the turbot stock dynamics, prasanted in a separate section together with that for the remaining commercial fish species.

TABLE 75. Turbot biomass (in thousand tonnas) in the Bleck Sae and in the waters of the former USSR during the periods 1970-1984 and 1989-1993

Yaars	Tha minimum biomasa of turbot in the waters of formar USSR	Turbot biomasa in tha Black Sea according to YugNIRO trawl aurvaya	Turbot biomaas in the Black Sea (VPA results)	Turbot biomasa in the Black Saa aa asaeaaed by tagging
1970	5.3			
1971	3.1			
1972	3.0			
1973	3.7			
1974	1.7			
1975	1.3	28.0	9.2	
1976	1.6	28.0	10.3	
1977	2.0	26.7	12.3	
1978	2.2	14.0	9.6	
1979	5.4	13.3	15.8	
1980	2.8	10.0	15.1	
1981	3.3	9.3	17.2	
1982	4.7	8.0	18.9	
1983	5.3	5.3	20.0	
1984		8.3	19.0	
1975-1979*	2.5	22.0	11.4	19.1
1980-1984*	4.0	8.2	18.0	14.2
1989-1993**	9.9			

* according to data of Effimov *et al.* (1986)
** annual reports of YugNIRO

BLACK SEA MACKEREL, *SCOMBER SCOMBRUS* LINNAEUS

Due to its great commercial importance, the mackerel has been intensively studied in almost all Black Sea countries. However, there exist many discrepancies concerning the species biology that impeded the solution of the problem of rational exploitation of stocks (Ivanov, 1966). Mackerel landings have dramatically declined and since 1968 vanished along the coasts of Bulgaria, Romania and the former USSR (**Table 76**). During the period 1952-1968 the former Soviet Union had the highest landings averaging 1503.4 tonnes, or 49.42% of the total mackerel catch in the Black Sea (3042.2 tonnes). The next in size were the Turkish and Bulgarian catches amounting to 908.2 tonnes (29.85%) and 561.2 tonnes (18.45%), respectively. The Romanian landings were the lowest: 69.5 tonnes (2.28%). **Table 76** also shows that since 1968, mackerel are harvested only off the Turkish coast. The mean annual catch during the period 1969-1992 was 215.5 tonnes, i.e. one fourteenth of those during 1952-1968.

The Black Sea mackerel spawns in the Sea of Marmara (Zernov, 1913; Netchaev, 1941; Numman, 1954; Demir and Acara, 1955). However, some authors have reported the occurrence of fish in ripe running condition in the Black Sea, also (Drensky, 1922; Necheev, 1934, 1941; Zambriborz, 1955).

Migrations of mackerel can be inferred from fisheries' data, as well as from tagging of fish in the Bosporus and along the Bulgarian coast (Netchaev, 1933; Numman, 1956; Ivanov, 1966). Fishery statistical data show that the mackerel was fished heavily in the Bosporus in December-January and in April, off the Bulgarian coast in May-June and in November- December, and in the north-western part of the basin from July to September. The landings along the Anatolian and Caucasian coasts and in the Kertch Strait were insignificant and irregular (Ivanov, 1966). Therefore, the data given in **Table 77** are of great interest.

TABLE 76. Mackerel (*Scomber scombrus*) catches in the Black Sea (in tonnes) during the period 1942-1992

Years	Bulgaria	Romania	former USSR	Turkey	Total
1942	2025.0	113.0	161.7	1570.6	3870.3
1943	1868.0	5.0	183.0	1021.4	3077.4
1944	740.0	1.0	no data	2766.8	5009.6
1945	1026.0	50.0	286.0	1679.8	3041.6
1946	460.0	33.0	437.0	1843.7	2774.7
1947	326.0	20.0	386.0	933.0	1665.0
1948	344.0	29.0	141.0	1625.7	2139.7
1949	667.0	51.0	257.0	2159.0	3134.0
1950	1296.0	54.0	942.8	2716.8	5009.6
1951	318.0	10.5	380.0	1200.0	1908.5
1952	380.0	43.7	696.1	2274.5	3394.3
1953	941.0	31.6	1838.4	3260.0	6071.0
1954	1405.0	201.5	4871.9	1590.0	8068.4
1955	182.0	43.1	917.8	380.0	1522.9
1956	3.0	0.1	0.0	240.0	243.1
1957	4.0	1.2	0.0	70.0	75.2
1958	206.0	19.8	96.4	290.0	612.2
1959	438.0	68.7	1859.2	410.0	2774.9
1960	1526.0	104.1	1756.3	500.0	3886.4
1961	399.0	143.2	2091.9	500.0	3134.1
1962	672.4	233.4	1603.7	500.0	3011.5
1963	311.3	121.5	3223.3	960.0	4636.1
1964	1671.0	73.4	2156.2	550.0	4450.6
1965	974.5	96.1	2949.7	777.2	4797.5
1966	234.5	0.0	1327.4	2144.6	3706.5
1967	159.7	0.0	168.4	507.9	836.1
1968	32.3	0.0	0.0	485.0	517.3
1969	0.0	0.0	0.0	483.1	483.1
1970	0.0	0.0	0.0	522.9	522.9
1971	0.0	0.0	0.0	6.6	9.6
1972	0.0	0.0	0.0	175.7	175.7
1973	0.0	0.0	0.0	125.4	125.4
1974	0.0	0.0	0.0	0.2	0.2
1975	0.0	0.0	0.0	76.6	76.6
1976	0.0	0.0	0.0	4.1	4.1
1977	0.0	0.0	0.0	0.3	0.3
1978	0.0	0.0	0.0	30.1	30.1
1979	0.0	0.0	0.0	743.1	743.1
1980	0.0	0.0	0.0	4.0	4.0
1981	0.0	0.0	0.0	8.0	8.0
1982	0.0	0.0	0.0	9.0	9.0
1983	0.0	0.0	0.0	14.0	14.0
1984	0.0	0.0	0.0	23.0	23.0
1985	0.0	0.0	0.0	413.0	413.0
1986	0.0	0.0	0.0	247.0	247.0
1987	0.0	0.0	0.0	654.0	654.0
1988	0.0	0.0	0.0	534.0	534.0
1989	0.0	0.0	0.0	39.0	39.0
1990	0.0	0.0	0.0	56.0	56.0
1991	0.0	0.0	0.0	780.0	780.0
1992	0.0	0.0	0.0	224.0	224.0

TABLE 77. Turkish catches of mackerel (*Scomber scombrus*) in the Black Sea, Marmara, Aegean and Mediterranean during 1967-1992 (in tonnes)

Years	Eastern part of the Black Sea	Western part of the Black Sea	Black Sea Total	Sea of Marmara	Aegean Sea	White Sea (Mediterranean)	TOTAL
1967			836.1	2064.0	4.4	3.6	2580.0
1968			517.3	1131.8	21.4	12.9	1651.2
1969			483.1	115.7	20.9	3.6	620.8
1970			522.9	5.5	11.2	0.3	539.9
1971			6.6	16.4	14.7	0.0	37.7
1972	175.7	0.0	175.7	183.2	13.1	0.0	372.0
1973	0.0	125.4	125.4	194.1	78.8	0.6	398.9
1974	0.2	0.0	0.2	128.1	22.0	3.9	154.2
1975	64.8	11.8	76.6	366.3	40.2	5.3	488.4
1976	4.1	0.0	4.1	40.0	16.4	5.5	66.0
1977	0.0	0.3	0.3	88.4	31.6	75.2	195.5
1978	0.05	30.1	30.2	222.7	21.9	50.1	329.9
1979	664.9	78.2	743.1	42.9	16.1	12.4	814.5
1980	0.0	4.0	4.0	24.0	62.0	2.0	92.0
1981	0.0	8.0	8.0	51.0	134.0	7.0	200.0
1982	0.0	9.0	9.0	52.0	137.0	8.0	206.0
1983	0.0	14.0	14.0	263.0	154.0	14.0	445.0
1984	0.0	23.0	23.0	211.0	197.0	10.0	441.8
1985	0.0	413.0	413.0	948.0	62.0	30.0	1453.0
1986	37.0	210.0	247.0	168.0	108.0	0.0	523.0
1987	98.0	556.0	654.0	445.0	286.0	30.0	1385.0
1988	138.0	396.0	534.0	485.0	526.0	0.0	1545.0
1989	39.0	0.0	39.0	98.0	488.0	51.0	676.0
1990	12.0	44.0	56.0	266.0	455.0	0.0	777.0
1991	622.0	158.0	780.0	200.0	554.0	0.0	1534.0
1992	62.0	0.0	62.0	224.0	864.0	1.0	1151.0
Mean			237.1	336.0	133.7	12.5	719.3
%			32.96	46.71	18.59	1.74	100.0

As one cen see during the pariod 1967-1992 tha mean catch in tha Black Sea wes 237.1 tonnes (32.96%) and in the Marmara, Aagaan and White Saa (Maditarranean), 336 (46.71%), 133.7 (18.59%) and 12.5 tonnes (1.74%), raspectively, totalling 719.3 tonnes. It is quite curious that aftar the extinction of the spacias from tha north-western and westarn perts of the Black Sea including the Bulgarian coast, landings in the eastarn part (the Anatolian coast of Turkey to tha east of Sinop) increasad considerably. Tha averages cetch in the eastern part (east of Sinop) was 99.1 tonnas (52.05%) during the pariod 1972-1992 while that in the wastarn part (west of Sinop) was 91.3 tonnas (47.95%). From tha data prasented it is evident that mackeral is fished thara even now although tha species is considered extinct off 8ulgarian, Romanian and tha former USSR coasts. The problam is further complicated as tha Black Sea mackaral doas not differ morphomatricelly from the mackeral in tha Atlantic and Maditarranean (Ivanov, 1966), i.a. thay reprasant distinct populetions of ona and the same species (*Scomber scombrus*) characterised by their own biological paramaters (ege et first meturity, growth rete in length end weight, etc.). According to thasa peculiaritias, tha mackeral in the Black Sea, is more akin to that in the Maditerranean (Ivanov, 1966), making it almost impossible to distinguish them, especially in the Aegean Sea. The former has always been considarad to spawn in Marmara and trophically to be a Black Saa stock. For this raason it is very hard without spacial rasaarch to establish the population, the mackerel ceught at prasent balongs to the 8lack Sea or tha Maditarranean stock, sinca tha lattar has entered tha 8lack Sea in the past (Krotov, 1940; Zabriborz, 1955; Ivanov, 1966). The problem appears further more when taking into consideration that in thasa seas the Atlantic (Spenish) mackerel, *Scomber japonicus* is elso prasant. From **Table 78** it is seen that during the period 1967-1992 tha catches of tha latter spacies rangad betwean 112.3 and 32 280.0 tonnas, with a maen of 8 674.5 tonnes, i.a. sinca 1975 this species has predominated over the other (*Scomber scombrus*) nativa 8lack Sea mackerel stock.

It is also epparent that Turkish catches of *S. japonicus* in the 8lack Sea ware hervasted in its wastern part (wast of Sinop). Nevertheless off the 8ulgarian coast, tha catches wera nagligibla and wera not racorded in the fishery statistics. From our observations during the pariod 1985-1987, eround 40-60 kg wera occasionally capturad. It is also interesting to note that since 1988, catches of thasa specias hava steadily decreesed, eccompanied by their increese in the Aageen and Mediterranean, although the common trend hes been towards e decraase of total catchas. This indicates that the fish enters tha 8lack Sae when its biomass increasas, as a result of which its cepabilities for feeding in tha Marmara, Aegaan and Mediterranean ara lower. The current species distribution, primarily in the eastarn part of the 8lack Sea (aast of Sinop), mey be regarded as indirect evidence of the deterioratad conditions of lifa in the wastarn part of tha besin.

Table 79 shows the age composition of 8lack Sea *S. Scombrus* mackerel catches during the period 1952-1968. The lattar is reastimatad using Ukrainian data for the aga composition of the formar USSR catchas, as well as tha deta of Ivanov (1966) and Ivanov and 8everton (1985). The Romanian end Turkish data relate to the years when the size composition of tha cetches had baen determined . As was pointed out (**Table 77**) tha combinad catches of Bulgaria and tha formar USSR during the pariod 1952-1968 made up 68% of the total catch in the 8lack Sea, i.e. covered the major portion, thus making the age composition mentioned reprasentative and allowing stock assassments to ba carriad out. Tha VPA with tuning of F_{ST} for the oldest ege groups was used for this purpose.

TABLE 78. Mackerel (*Scomber japonicus*) catches in the Black Sea, Marmara, Aegean and Mediterranean during the period 1967 - 1992 (in tonnes)

Years	Eastern part of Black Sea	Western part of Black Sea	Black Sea Total	Sea of Marmara	Aegean Sea	White Sea	Grand total
1967			83.4	543.2	20.4	6.7	653.7
1968			5.6	259.6	25.1	45.6	335.9
1969			512.5	293.5	25.7	15.2	846.9
1970			7.3	38.1	62.7	4.2	112.3
1971			3.0	116.7	7.0	10.2	136.9
1972	2.4	240.6	243.0	349.0	68.5	25.5	686.0
1973	4.0	10.1	14.1	62.7	10.4	25.6	112.8
1974	0.0	10.5	10.5	357.3	12.0	20.0	399.8
1975	0.0	48.3	48.3	192.6	44.8	151.6	437.3
1976	13.3	3.1	16.4	545.7	591.0	170.1	1323.2
1977	0.0	24.8	24.8	1150.4	376.9	114.2	1666.3
1978	12.0	205.0	217.0	765.3	532.7	95.1	1610.1
1979	0.0	2134.6	2134.6	794.9	90.9	65.6	3086.0
1980	0.0	1936.0	1936.0	1971.0	364.0	67.0	4338.0
1981	0.0	1483.0	1483.0	3062.0	295.0	132.0	4972.0
1982	0.0	2687.0	2687.0	5548.0	537.0	239.0	9011.0
1983	0.0	646.0	646.0	2296.0	602.0	511.0	4055.0
1984	0.0	935.0	935.0	940.0	770.0	364.0	3099.0
1985	2262.0	12796.0	15058.0	4695.0	1669.0	818.0	22700.0
1986	594.0	8231.0	8825.0	15600.0	1634.0	1315.0	27400.0
1987	693.0	9597.0	10290.0	18190.0	2132.0	1348.0	31960.0
1988	1293.0	10517.0	11810.0	16500.0	2455.0	1515.0	32280.0
1989	416.0	10631.0	11047.0	11209.0	2158.0	1886.0	26300.0
1990	1264.0	5515.0	6779.0	5956.0	4002.0	2413.0	19150.0
1991	686.0	6744.0	7430.0	1476.0	3512.0	2260.0	14678
1992	0.0	3691.0	3691.0	2625.0	3345.0	5101.0	14762
Mean	344.7*	3718.4*	3305.3 4063.1*	3674.5	974.7	720.0	8674.5
%	8.48*	91.52*	38.10 100.00*	42.36	11.24	8.30	100.00

TABLE 79. Age composition in numbers (x 10^{-6}) of total mackerel (*S. scombrus*) catches in the Black Sea during 1952 - 1968

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	CN	W
1952	9.9744	15.0062	3.3154	0.7941	0.1829	0.0034	29.2764	115.94
1953	29.1121	30.6204	3.1182	0.3580	0.0732	0.0076	62.7315	96.78
1954	9.2813	50.9778	7.5967	0.2420	0.4404	0.0047	68.5429	117.71
1955	0.0001	5.8123	4.1935	0.1894	0.0286	0.0000	10.2249	148.94
1956	0.6286	0.5013	0.2533	0.2989	0.0107	0.0000	1.6928	143.61
1957	0.3742	0.1783	0.0812	0.0367	0.0072	0.0000	0.6776	110.97
1958	5.7640	0.0650	0.0057	0.0013	0.0002	0.0000	5.8362	104.90
1959	14.8774	10.4684	1.0525	0.0396	0.0000	0.0000	26.4379	104.96
1960	14.1240	16.6310	1.7389	0.3525	0.0479	0.0000	32.8943	118.15
1961	5.8795	12.1199	5.2408	0.2153	0.0298	0.0077	23.4930	133.41
1967	8.6878	10.6650	5.1815	0.4831	0.0647	0.0065	25.0884	120.04
1963	2.4073	21.1060	6.0774	1.9727	0.1734	0.0167	31.7535	146.00
1967	14.9457	10.2886	9.1876	1.1514	0.0953	0.0098	35.6783	124.74
1965	11.6562	17.9387	4.9528	1.2281	0.3172	0.0423	36.1353	132.76
1966	1.1818	8.3870	10.0343	1.4409	0.8457	0.1721	22.0618	168.01
1967	3.3259	0.3459	0.6178	0.7261	0.6130	0.3764	6.0050	139.23
1968								

On the basis of the aga compositon of tha Bulgarian catches es well as of its predators' catches Ivanov and Beverton (1985) noted that during the periods 1954-1958 and 1959-1965 the Z, M and F values were as follows:

Total mortality	1954 - 1958				1959 - 1965			
	Age				Age			
	1	2	3	4	1	2	3	4
Z_t	1.83	2.53	3.22	-	1.14	1.97	2.93	4.02
M_t	1.39	2.08	2.77	-	0.69	1.52	2.48	3.57
F_t	0.44	0.45	0.45	-	0.45	0.45	0.45	0.45

The above values of F_t and M_t were obtained undar tha assumption that during the two periods the fishing mortality rates by age groups were equal.

According to the data of average age composition of the total catches, during the same two periods the Z values are the following:

Total mortality	1954 - 1958					1959 - 1965				
	Age					Age				
	1	2	3	4	Mean	1	2	3	4	Maan
Z_t	1.56 2.206	2.76		0.46	4.65	1.09	1.82	2.14	2.04	1.813

* The mean values of Z were estimated by linear regression between tha mean numbers of the corresponding age groups.

From the above values, apparently the meen Z valua wes lowar by roughly 0.393 during the second period. This may be expleined in two ways. The first assumes that the decline in mean Z is due to the lowered fishing effort. Tha second essumes that the maen M decreased owing to the depletion of predators (bonito and blua fish to a certain extent). Ivanov and 8everton (1985) believed the sacond hypothesis, adopting e constent fishing mortelity rete during the two periods of F = 0.45. From the author's date for M_t the meen velues ware reteined to be 1 514 and 0.960 for the corresponding periods. Working on the mean Z values as estimated by us, it was established that the mean F velues have been 0.692 and 0.853 respectively. These agree well with the fishary statistical data, showing that the average mackerel landings in the Black Sea during the two periods concerned have been 2 855.3 tonnes (1954-1958) and 3 813.0 tonnes (1959-1965). Consequently, the average catch hes increased by 1.34 times during tha second period and the maen value of F by 1.23 times. This is because the magnitude of the catches depends on tha fishing effort, but also on the stock size. Therefore, when conducting the VPA for the different periods, initially the following mortality coefficients wera used:

Mortality rates	1952-1953	1954-1958	1959-1965	1966-1968
F_{ST}	0.692	0.692	0.853	0.377
M	0.960	1.514	0.960	1.241
Z	1.652	2.206	1.813	1.618

* the average catch in the Black Sea during the period 1966 - 1968 was 1686.6 tonnes, by reason of which the figure 0.377 was applied as initial value for F_{ST}.

During the period 1966-1968 the everage bonito lending was 18 545.5 tonnes, while in 1954-1958 it wes 36 250.0 tonnes. 8eering in mind that the difference between tha meen values of M during 1954-1958 and 1959-1965 wes 0.55 it hes been concluded that during 1966-1968 M was probably around 1 241.

Tha maen waights et age used ara those of Ivanov (1966) for the spring when the species completas the corresponding biological ege end therefore the estimeted initial biomess coincides with the initial exploited biomass that is recruited in autumn. Hence, the estimated exploited stocks (81 +) in spring ere almost equel to the spewning stock size.

Tables 80, 81 and **Figure 27** present the VPA results with tuning of the values for the oldest age groups.

TABLE 80. Stock assessment (in numbers x 10^{-6} and x 10^{-3} tonnes) of mackerel in the Black Sea in the period 1952 - 1968

Year	0+	1,1+	2,2+	3,3+	4,4+	5,5+	B0+	B1+
1952	219.23	37.79	13.03	1.42	0.29	0.01	27.84	4.82
1953	400.26	80.71	6.39	3.21	1.29	0.02	49.74	7.72
1954	103.98	140.84	14.70	0.79	1.06	0.01	24.22	13.30
1955	37.08	19.00	11.56	0.56	0.08	0.00	6.87	2.97
1956	43.62	8.16	1.91	0.95	0.05	0.00	5.61	1.03
1957	77.52	9.33	1.58	0.32	0.09	0.00	9.14	1.0
1958	140.19	16.90	1.98	0.31	0.05	0.00	16.36	1.64
1960	171.03	28.41	3.69	0.03	0.00	0.00	20.73	2.77
1960	208.42	56.72	6.00	0.81	0.14	0.00	27.16	5.27
1961	223.30	71.46	12.24	0.03	0.12	0.03	30.76	7.32
1962	415.48	82.01	20.31	1.79	0.23	0.03	52.88	9.26
1963	199.61	153.92	25.16	4.80	0.41	0.05	37.03	16.07
1964	229.46	75.00	46.59	6.14	0.74	0.06	36.62	12.53
1965	65.75	79.03	22.70	12.52	1.68	0.23	18.13	11.22
1968	5.81	18.40	19.92	6.63	4.07	0.06	6.13	5.52
1967	7.23	1.11	1.56	1.34	1.06	0.77	1.56	0.52
1968	33.76	0.60	0.16	0.17	0.07	0.03	4.33	0.11

TABLE 81. Fishing mortality rate of mackerel in the Black Sea during the period 1952-1968

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	F
1952	0.0720	0.8499	0.4730	1.4730	1.8555	1.1673	1.1628
1953	0.1172	0.7757	1.1643	0.1848	1.5195	0.9208	0.9111
1954	0.1856	0.9858	1.7572	0.7838	1.2184	1.2184	1.1863
1955	0.0001	0.7812	0.9885	0.8999	0.9780	0.0000	0.9119
1956	0.0283	0.1250	0.2854	0.8142	0.4957	0.0000	0.4301
1957	0.0094	0.0376	0.1035	0.2466	0.1603	0.0000	0.1370
1958	0.0824	0.0075	0.0057	0.0079	0.0079	0.0000	0.0072
1959	0.1437	0.7770	0.5535	0.1517	0.0000	0.0000	0.3705
1960	0.1104	0.5733	0.7172	0.9849	0.6865	0.0000	0.7405
1961	0.0417	0.2981	0.9648	0.4257	0.4854	0.5437	0.5435
1962	0.0330	0.2217	0.4819	0.5182	0.5333	0.4391	0.4388
1963	0.0189	0.2350	0.4509	0.9072	0.9569	0.6383	0.6375
1964	0.1059	0.2351	0.3544	0.3346	0.2184	0.2862	0.2856
1965	0.3135	0.4183	0.3991	0.1634	0.3366	0.3299	0.3293
1966	0.4167	1.2304	1.4574	0.5265	0.4274	0.9114	0.9104
1967	1.2488	0.7101	0.9932	1.6622	2.1668	1.3879	1.3831
1968	0.1856	0.5336	0.7245	0.6729	0.7940	0.6812	0.6813

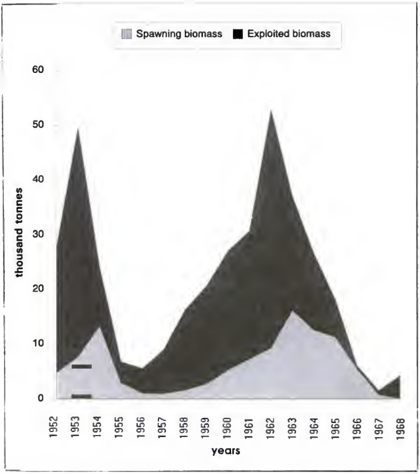


FIGURE 27. Spawning and exploited biomasses of mackerel in the Black Sea

From **Table 80** it can be seen that the initial (May-June) exploited stock (B_{1+}) varied between 112 (1968) and 16070 tonnes (1963) during the period 1952-1968. The seme stock at the end of July-August receives recruits of mackerel offspring that are intensively caught off the former USSR, Romenien and Bulgarian coest, mainly during in the eutumn (September-November). This stock moves along the coest of the above-mentioned countries towerds its wintering grounds in the Sea of Marmare, where it spawns in the next year (April). The Bleck Sea mackerel populetion matures when the fish become one year old (Ivanov, 1966).

The strong variations of total exploited biomass (B_{0+}) are due to the diffarent abundance of the particuler yeer clesses. During tha period under consideration this biomass has renged from 1580 (1967) to 52800 tonnas (1962). The strongest year classes heve been those of 1962 (415.5×10^{-6}) and 1953 (400.3×10^{-6}). Conversely, the 1966 and 1967 year classas have been low in abundance (5.81 x 10-6 end 7.23 x 10-6, respectively). Besides, thesa year classes have been subject to en intensive elimination from the commercial fishery. The values of F during the corresponding yeers were 0.4167 and 1.2488. This is also the period when the mackerel predetors showed major growth in stock size (1968-1972).

In **Teble 82** ere shown the parameters in the following equations:

(12) $R = e^*B^*\exp(-bB)$

(13) $R = a^*B^*\exp(-bB - cY)$

(14) $R = a + bB - cY$

R - number of 0+ yeer old fish of mackerel; B - meckerel spawning biomess (Â1 +); Y - bonito catch

TABLE 82. Values of the parameters "a", "b" and "c" in the equations (12) - (14)

Peremeters	Equation 12	Equetion 13	Equetion 14
a	51.283445	53.696925	111.8385
b	0.1149556	0.1169585	13.0746
c		0.0022465	2.6223
Bopt	8.699	8.550*	
Rmax	164.117	168.897*	
r	0.4762	0.4864	0.4480
D%	22.68	23.66	20.07
S%	77.32	76.34	79.93

* - et Y = 0

In **Teble 83** ere given the paremeters in the following equtions:

(15) $Y = e - bX1$; (16) $Y = e - cX2$; (17) $Y = e - dX3$

(18) $Y = a - bX1 - cX2 - dX3$

(19) $Y = a - bX1 - cX2 - dX3 - eX4 - fX5 - gX6$

Y is the catch of mackerel during the year observed; X_1 is tha catch of bonito during the previous yeer; X_2 is the catch of blue fish during the previous yeer; X_3 is tha catch of mackerel during the previous year; X_4, X_5 end X_6 ere the summerised catches, respectively of bonito, blue fish end mackerel during the previous 2 years.

TABLE 83. Values of the parameters in the equations (15) - (19)

Parameters	Equation (15)	Equation (16)	Equation (17)	Equation (18)	Equation (19)
a	429.1708	755.7533	382.6174	693.4530	721.8199
b	0.3410			0.3435	0.4523
c		1.4805		0.3244	0.2936
d			-0.3933	-0.3936	-0.6897
e					-0.0912
f					0.1978
g					0.1526
r	0.459	0.350	0.388	0.604	0.628
D%	21.07	12.25	15.05	36.48	39.44
S%	78.93	87.75	74.95	63.52	60.56

It is seen that mackerel catches increase inversely to the bonito and blue fish catches during previous years, and vice-versa. Hence, if the values of the catches of the three species are adequate to the size of their stocks, than Ivanov's and Beverton's (1985) conclusions, are true. According to these authors, strong declines of mackerel stocks have been recorded during 1892-1894, 1910-1914, 1935-1939, 1955-1958 and from 1966 till now. During the first 4 periods the decline of mackerel stocks has been caused by a considerable increase in the biomass of bonito and blue fish, which are predators of the youngest mackerel group (0+). However, during the periods pointed out, the blue fish stocks have been under the mean annual level, because of which the mackerel managed to overcome the negative consequences of growth in abundance, and biomass of bonito. Practically the almost complete disappearance of mackerel from the Black Sea after 1968 was determined by the coincident increase of bonito and the blue fish stocks and also by the increased fishing mortality on the recruitment, especially in 1966 and 1967. Since mackerel spawns in the Sea of Marmara that is much smaller than the Black Sea, the possibility of mackerel offspring avoiding its predator is considerably lower. Probably this is the major reason for the Black Sea mackerel population almost disappearing; in 1968 its total biomass (B0+) dropped to 4 332 tonnes. In the same year the offspring biomass was 4 220 tonnes and the bonito catch reached its maximum value (27 969.2 tonnes).

The disastrous decline of the mackerel stock and the almost full disappearance of this species in the Black Sea proves without any doubt, the necessity for a new ecological approach to exploitation of the living resources with a view to their preserving and recovery.

According to the theory of the dynamics of fish populations the total allowable catch (TAC) or maximum sustainable yield (MSY) are defined by means of theoretically derived values for $F_{opt} = F_{0.1}$ or F_{msy}. However, when estimating these mortality coefficients, the influence of various abiotic and biotic factors of the environment is rarely taken into consideration.

It is assumed (Prodanov, 1990) that the values of the coefficient mentioned are not constant, and depend on the size of the stock and on the abundance of its predators, since the latter ones have a direct effect on the level of its natural mortality. The same involves the environmental conditions which in some years are favourable for the reproduction and survival of new generations, and in others, just the contrary.

On the basis of Ivanov and Beverton's data (1985) for the level of the natural mortality coefficient and weight growth by age groups of mackerel during 1955-1958 and 1959-1965, it is established that in tha first period $F_{0.1} = F_{msy}$ had to be 0.09 end in the second, 0.58 (See Figure 28 and box).

During years 1966-1969 the situation had been as in 1955-1958, i.e high predator abundance. The fishing mortality was 0.60-1.38 instead of 0.09. Hence, en irrational increase in the mackerel fishery at the time of increase of its predators is the main cause for dramatic collapse of mackerel stocks.

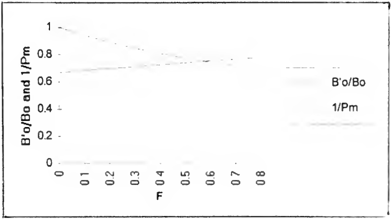


Fig. 28a Determining of the F_{opt} value at $C_{max} = Y_E$

The B'_0/B_0 ratio decreases with F et a constant recruitment with normal levels of netural mortality (1959-1965).

The $1/P_m$ ratio increases with F reflecting the growth in weight by age groups of mackerel during the period 1959-1965. $F_{opt} = 0.58$

For more details see Prodanov (1989).

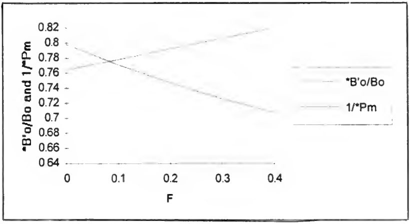


Figure 28b. Determining of F_{opt} velue et $C_{max} = Y_E$

The $*B'_0/B_0$ ratio decreases at constant recruitment, increased natural mortelity end increesed weight growth by age groups.

The $1/*P_m$ ratio increeses with F reflecting the weight growth by age groups of mackerel during the period 1954-1958.

$$F_{opt} = 0.09$$

The second case shows that with increese of netural mortality, the mackerel stock will begin to decline if the recruitment does not increase, despite increesed growth in weight by ege groups. In order to avoid the stock decline due to the negative impact of the predetors in this situation, it is necessary to abruptly decrease the fishing mortality.

BONITO, *SARDA SARDA* LINNAEUS

The bonito is a wide-spread fish species in the Black Sea, Marmara, Aegean and Mediterranean Seas. It migrates in a similar way to the mackerel. In spring the fish enter the Black Sea for feeding and spawning and in late autumn turn back for wintering in the Marmara and Aegean Seas. They attain sexual maturity at 1 to 2 years of age and at lengths of 40-45 cm. This fish species has a short life span and a high growth rate. The maximum length and weight the bonito approaches are 103 cm and 9.7 kg respectively (Nikolov, 1960; Ivanov and Beverton, 1985).

In **Table 84** the bonito landings in the Black Sea during the period 1950-1992 (in tonnes) are shown.

TABLE 84. Bonito landings in the Black Sea during 1950-1992 (in tonnes)

Years	Bulgaria	Romania	former USSR	Turkey	Total
1950	450.7	10.0	40.0	5695.0*	6195.7*
1951	37.4	1.0	40.0	1752.0	1830.4
1952	152.5	0.0	30.0	3505.0	3687.5
1953	308.6	1.0	20.0	9200.0	9529.6
1954	2192.2	93.0	250.0	14700.0	17235.2
1955	1033.9	164.0	1540.0	49200.0	51937.9
1956	1405.1	306.0	5580.0	55500.0	62791.1
1957	1015.1	317.0	8630.0	39900.0	49862.1
1958	1110.3	164.0	4180.0	27200.0	32654.3
1959	1034.9	40.0	200.0	19650.0	20924.9
1960	3193.6	171.0	210.0	12100.0	15674.6
1961	532.2	47.0	350.0	42900.0	43829.2
1962	34.8	10.0	10.0	4600.0	4654.8
1963	248.1	0.0	20.0	20400.0*	20668.1*
1964	562.7	1.0	10.0	6959.2	7532.9
1965	1683.1	14.0	40.0	12800.0	14537.1
1966	1475.0	4.0	270.0	9320.0	11069.0
1967	2281.1	1.0	30.0	8813.9	11126.0
1968	1015.4	1.0	20.0	9730.4	10766.8
1969	1576.4	2.0	10.0	18750.9	20339.3
1970	29.6	0.0	0.0	13082.0	13111.6
1971	40.6	0.0	0.0	20835.0	20875.6
1972	0.0	0.0	0.0	10091.9	10091.9
1973	27.7	0.0	0.0	3208.2	3235.9
1974	15.6	0.0	0.0	3786.2	3801.8
1975	0.4	0.0	0.0	3073.0	3073.4
1976	39.8	0.0	0.0	2383.2	2423.0
1977	44.2	0.0	0.0	3493.5	3537.7
1978	10.7	0.0	0.0	4079.4	4090.1
1979	0.7	0.0	0.0	8075.8	8076.5
1980	13.4	0.0	0.0	13486.4	13499.8
1981	190.7	0.0	0.0	757.0	947.7
1982	3.3	0.0	0.0	18415.0	18418.3
1983	23.6	0.0	0.0	23206.0	23229.6
1984	0.9	0.0	0.0	2258.0	2258.9
1985	0.7	0.0	0.0	10668.0	10668.7
1986	0.2	0.0	0.0	8327.0	8327.2
1987	13.1	0.0	0.0	13140.0	13153.1
1988	0.0	0.0	0.0	13596.0	13596.0
1989	0.5	0.0	0.0	3803.0	3803.5
1990	16.7	0.0	0.0	11207.0	11223.7
1991	0.0	0.0	0.0	15857.0	15857.0
1992	0.0	0.0	0.0	6211.0	6211.0

* Turkish landings during the period 1950-1963 are considered in the four above-mentioned seas.

Tha magnitude of Turkish bonito catches, by regions, during 1967-1992 are prasantad in **Table 85.**

It is seen that during the period 1967-1992 the average bonito catchas in tha Black Saa (9 628.3 tonnas) represantad 72.37% of the everage total catch (13 306.6 tonnes). Next in siza wara the catchas in tha Saa of Marmara: 23.06% (3 067.1 tonnas), whila those in the Aegaan and Mediterranaan Seas were insignificant (overell 4.57%).

It appaars from the above that even at present bonito landings are highest in tha Black Saa. Beceuse of this, the fact that the bonito does not migrate towards the north-wastarn part of the basin provas its incraasing pollution and arises a certain interest. This is presumably tha major reeson for the sharp dacline of bonito catches along Bulgarian, Romenien and tha former USSR coasts.

TABLE 85. Turkish landings of bonito by ragions during 1967-1992 (in tonnes)

Year	Eastern part of Bl. Sea	Wastarn part of Bl. Sea	Black Sea Total	Sea of Marmara	Aegean Sea	Medi-terra-nean	Grand Total
1967	-	-	8813.9	10179.4	107.2	33.2	19133.7
1968	-	-	9730.4	9027.2	154.9	112.6	19025.1
1969	-	-	18750.9	27969.2	157.9	69.0	46947.0
1970	12485.7	596.3	13082.0	2476.2	214.7	59.3	15832.2
1971	19935.1	899.9	20835.0	2829.1	35.0	16.4	23800.5
1972	9245.6	846.3	10091.9	1534.3	31.9	96.9	11755.0
1973	2269.2	939.0	3208.2	327.1	73.3	45.0	3653.6
1974	3260.7	525.5	3786.2	1337.7	91.1	71.6	5286.6
1975	2398.6	674.4	3073.0	846.9	148.5	71.6	4140.0
1976	1554.7	828.5	2383.2	362.5	207.0	72.3	3025.0
1977	1161.9	2331.6	3493.5	663.6	77.9	103.5	4338.5
1978	1450.9	2628.5	4079.4	1013.5	174.6	163.2	5430.7
1979	7294.3	781.5	8075.8	283.1	82.0	198.3	8639.2
1980	11604.6	1881.8	13486.4	939.2	151.2	333.2	14910.0
1981	306.0	451.0	757.0	332.0	17.0	20.0	1126.0
1982	7928.0	10487.0	18415.0	4502.0	393.0	87.0	23397.0
1983	8538.0	14668.0	23206.0	5072.0	635.0	121.0	29034.0
1984	520.0	1738.0	2258.0	4064.0	812.0	86.0	7220.0
1985	7178.0	3490.0	10668.0	835.0	524.0	254.0	12281.0
1986	3313.0	5014.0	8327.0	1387.0	630.0	412.0	10756.0
1987	5228.0	7912.0	13140.0	2189.0	994.0	650.0	16973.0
1988	5556.0	8040.0	13596.0	1317.0	2122.0	578.0	17613.0
1989	1936.0	1867.0	3803.0	492.0	156.0	216.0	4667.0
1990	4057.0	7150.0	11207.0	1942.0	863.0	375.0	14387.0
1991	7006.0	8851.0	15857.0	2009.0	986.0	299.0	19151.0
1992	3394.0	2817.0	6211.0	1014.0	980.0	549.0	8654.0
Average			9628.3	3067.1	412.3	195.9	13306.6
%			72.37	23.06	3.10	1.47	100.00

Pracisa racant astimatas for bonito biomass ara not available. According to Ivanov and Bevarton (1985) it varies between 10 000 and 200 000 tonnes.

As it is wall-known, tha bonito forages primarily on anchovy, horse mackerel, young mackaral and considerably less on sprat, blotched pickerel, young mullats, etc. For this raeson the bonito holds a significant place in tha trophic interraletions betwean pelegic fishas. However the leck of ragular biological research on this species does not parmit the use of a number of biostetistical methods. That is why bafore such data becoma eveileble the bonito biomass should ba roughly essessed by scientific cruises, mainly in the Sea of Marmara during tha tima of its overwintering.

BLUE FISH, *POMATOMUS SALTATOR*, LINNAEUS

The blue fish, like the bonito, enters the Black See in spring for feeding and spawning end moves back to the Sea of Marmara in winter. The spawning peak occurs in July and the first half of August. It feeds primarily on fish (anchovy, horse mackerel end young meckerel) and partially on crustaceans (shrims). **Table 86** presents the blue fish cetches during the period 1950-1992.

TABLE 86. Blue fish catches by countries in the Black Sea during the period 1950-1992 (in tonnes)

Year	Bulgaria	Roumania	• former USSR	Turkey	Total
1950	10.4	-	-	-	
1951	67.2	-	-	-	
1952	107.2	-	-	-	
1953	25.6	-	-	-	
1954	70.2	-	-	-	
1955	74.1	-	-	-	
1956	103.0	-	-	-	
1957	86.9	-	-	-	
1958	38.6	-	-	-	
1959	57.3	-	-	-	
1960	59.6	-	-	-	
1961	36.8	-	-	-	
1962	35.6	-	-	-	
1963	6.1	-	-	-	
1964	8.1	0.0	-	600	608.1
1965	23.1	0.0	-	480.0	503.1
1966	160.2	0.0	-	1900.0	2060.2
1967	464.0	0.0	-	2742.8	3206.8
1968	695.5	0.0	-	1905.4	2600.9
1969	361.5	0.0	400.0	2032.0	2793.5
1970	504.6	0.0	400.0	4665.1	5569.7
1971	67.4	0.0	0.0	1759.0	1826.4
1972	0.2	0.0	0.0	1653.2	1653.4
1973	0.0	0.0	0.0	208.4	208.4
1974	6.0	0.0	0.0	211.1	217.1
1975	15.3	1.0	7.0	2149.1	2172.4
1976	62.3	6.0	11.0	7819.0	7898.3
1977	22.6	6.0	41.0	8560.8	8630.4
1978	85.5	1.0	19.0	3309.8	3415.3
1979	21.3	2.0	0.0	13693.3	13716.6
1980	24.4	0.0	11.0	6951.0	6986.4
1981	40.9	6.0	0.0	12017.0	12063.9
1982	8.1	7.0	8.0	23285.0	23308.1
1983	3.7	2.0	3.0	22887.0	22895.7
1984	12.5	0.0	0.0	5135.0	5147.5
1985	0.4	0.0	0.0	7373.0	7373.4
1986	4.6	0.0	0.0	9260.0	9264.6
1987	4.4	0.0	1.0	8195.0	8200.4
1988	0.9	0.0	0.0	9465.0	9465.9
1989	0.1	0.0	2.0	6528.0	6530.1
1990	6.4	0.0	0.0	5733.0	5739.4
1991	0.2	0.0	0.0	9013.0	9013.2
1992	0.0	0.0	0.0	4700.0	4700.0
Average	92.7	1.1	32.5	6496.6	6622.9
%	1.40	0.02	0.49	98.09	100.00

It is sean that Turkish cetches of blue fish rapresent on everega 98.09% of the total blua fish catches in the Bleck Sea. For this reason we axamine in more detail the distribution of Turkish catches by regions and seas (Table 87).

TABLE 87. Turkish catches of blue fish by regions and seas during the period 1967-1992 (in tonnes)

Year	Eastern part of Bl. Sea	Western part of Bl. Sea	Black Sea Total	Sea of Marmara	Aegean Sea	Medi-terra-nean	Grand Total
1967	-	-	2742.8	3327.7	56.5	41.8	6168.8
1968	-	-	1905.4	2456.9	88.8	94.4	4545.5
1969	-	-	2032.0	2291.0	51.2	64.8	4439.0
1970	4014.2	650.9	4665.1	1981.8	76.2	52.5	6775.6
1971	1198.6	560.4	1759.0	2430.9	58.2	154.1	4402.2
1972	1102.6	550.6	1653.2	2103.8	53.2	139.8	3950.0
1973	127.6	80.8	208.4	141.7	10.2	20.0	380.3
1974	121.5	89.6	211.1	583.0	27.3	53.1	874.5
1975	293.4	1855.7	2149.1	550.4	81.4	59.8	2840.7
1976	5687.1	2131.9	7819.0	642.6	292.5	57.1	8811.2
1977	3674.3	4886.5	8560.8	1111.2	203.7	112.2	9987.9
1978	777.7	2532.1	3309.8	694.5	44.1	195.9	4244.3
1979	6553.5	7139.8	13693.3	1209.4	22.3	203.9	15128.9
1980	994.0	5957.0	6951.0	3202.0	34.0	119.0	10306.0
1981	3594.0	8423.0	12017.0	5938.0	267.0	208.0	18430.0
1982	8576.0	14709.0	23285.0	8369.0	366.0	164.0	32184.0
1983	5293.0	17594.0	22887.0	6778.0	573.0	615.0	30854.0
1984	4663.0	472.0	5135.0	5431.0	733.0	438.0	11737.0
1985	4900.0	2473.0	7373.0	570.0	267.0	173.0	8383.0
1986	1109.0	8151.0	9260.0	2639.0	185.0	167.0	12251.0
1987	981.0	7214.0	8195.0	2335.0	159.0	153.0	10842.0
1988	2135.0	7330.0	9465.0	1405.0	503.0	449.0	11822.0
1989	1538.0	4990.0	6528.0	3347.0	994.0	207.0	11076.0
1990	199.0	5534.0	5733.0	2933.0	520.0	274.0	9460.0
1991	1294.0	7719.0	9013.0	2509.0	497.0	315.0	12334.0
1992	172.0	4528.0	4700.0	3704.0	977.0	316.0	9697.0
Average			6972.0	2641.7	274.6	186.4	10074.7
%			69.20	26.22	2.73	1.85	100.00

The averaga catch in tha Black See (6 972.0 tonnes) represents 69.72% of totel blue fish catches (10 074.7 tonnes). Next are the cetches in the Sae of Marmera: 26.22% (2 641.7 tonnes). The lendings from Aegeen end Mediterranean Sees are insignificent - their avaraga combinad catch is 461.0 tonnes (4.58% of the mean totel blue fish catch).

It appears from the same Table that blue fish cetchas ere taken primerily in the western half of the Black Sea, i.e. west of Sinop. Tha avaraga cetch during tha period 1970-1992 is 5024.9 tonnes; that is 66.20% of tha everage total catch in tha Black Sea. Thay are teken most probably in the Bosporus or in its vicinity during the spring migrations towerds the Bleck See. Tha blue fish caught aast of Sinop confirms tha negetiva impect of pollution of the basin, espacially in its wastarn part, since in the lest 10-15 yeers the blua fish has baan absent along the coests of Bulgarie, Romania end Ukraine.

The blue fish, like the bonito, is a significent component in tha trophic interreletions between pelagic fishas. All this strasses the necassity of yaarly essassmants of its biomass siza. As was the casa with bonito, regular biologicel investigations have not been carried out, which makas it impossibla to apply biostatistic methods for essessing blue fish stocks.

MULLETS, FAMILY *MUGILIDAE*

The mullets are represented by 5 species in the Black Sea; the golden mullet (*Liza aurata*), the leaping grey mullet (*Lisa saliens*) and the grey mullet (*Mugil cephalus*), are the three main species having e commercial importance. However, the catches have not been separated by specias (**Table 88**), except for the former USSR as well as the Bulgarian catches during certain years. 8eceuse of this, en eccurete assessment of their stocks is impossible.

From **Table 88**, it is evident that the Turkish mullet catches represent B7.99% of their total catches in the 8lack See. They ere ceught primarily along the eestern Anetolien coest, eest of Sinop (76.40%).

TA8LE 88. Mullets catches (in tonnes) by countries in the Black Sea during the period 1967-1992

Years	Bulgaria	Romania	former USSR	Turkey *	Turkey **	Turkey Total	Grand total
1967	47.9	-	900.0			3018.3	3966.2
1968	27.8	-	700.0			2312.1	3039.9
1969	12.7	-	400.0			2530.4	2934.4
1970	8 1	-	300.0	4473.8	227.2	4701.0	5009.1
1971	8.9	-	200.0	2006 4	225.8	2232.2	2441.1
1972	18.7	-	300.0	1114.0	144.8	1258.8	1577.5
1973	5.3	-	400.0	600.8	141.2	742.0	1147.3
1974	12.1	1.0	400.0	872.5	144.8	1017.3	1430.4
1975	10.0	1.0	400.0	721.0	272.5	993.5	1404.5
1976	14.7	5.0	320.0	901.8	145.0	1046.8	1386.5
1977	5.7	2.0	270.0	1030.2	399.4	1429.6	1707.3
1978	7.8	2.0	110.0	712.8	499.9	1212 7	1332.5
1979	19.5	1.0	280.0	2759.2	1082.9	3842.1	4142.6
1980	6.3	1.0	90.0	2317.0	310.0	2627.0	2724.3
1981	10.1	15.0	280.0	1258.0	441.0	1699.0	2004.1
1982	2.7	2.0	250.0	2122.0	444.0	2566.0	2820.7
1983	26.1	0.0	310.0	2285.0	573.0	2858.0	3194.1
1984	5.6	0.0	420.0	1013.0	829.0	1842.0	2267.6
1985	1.5	0.0	300.0	1606.0	781.0	2487.0	2788.5
1986	4.9	2.0	360.0	870.0	525.0	1395.0	1761.9
1987	9.3	0.0	170.0	1034.0	624.0	1658.0	1837.3
1988	2.5	0.0	170.0	1636.0	700.0	2336.0	2508.5
1989	3.1	8.0	400.0	1842.0	1001.0	2843 0	3254.1
1990	0.5	0.0	30.0	1173.0	576.0	1749.0	1779.5
1991	-	0.0	20.0	2113.0	1913.0	4026 0	4046.0
1992	-	0.0	20.0	1478.0	880.0	2358.0	2378.0
Average	10 5	1.5	286.1			2183.9	2482.0
%	0.42	0.06	11.53			87.99	100.00

* - Turkish catches in the eastern part of the 8lack Sea
** - Turkish catches in the western part of the Black Sea

GOLDEN MULLET, *LISA AURATA* RISSO

The golden mullet is the most abundant mullet species, which catches highly predominete over that of the other two species. According to YugNIRO data, the golden mullet catches represent eround 98% of the total mullets catches of the former USSR. According to Alexandrova (1973) the percentage proportion among the three species in the Bulgerien cetches from the near shore lakes and the 8lack Sea ere es follows (**Tebles 89** end **90**). This author also states that the differences (in parcentage) in tha ratio between these three species are due to the different salinity levels in the basın. The grey mullet sustains better a lowar salinity in the neer shore lakes, while the golden mullet prefers higher saline waters, so it rarely enters the lekes except for young individuels.

The golden mullet spawns ın the Black Sea in June-August. Its fecundıty varıes from 800 000 to 3 million eggs. The males mature at 2-3 years of age and at lengths of 28-30 cm. The eggs end larvae develop in the surface weters until the young of the yeer golden mullet reech 5-6 cm by the end of October. The latter mıgrate towerds the shore where they winter ın suitable bays.

TA8LE 89. Percentage composition of the thrae specıas in the Bulgerian cetches from the near shore lakes (Alaxandrova, 1973)

Year	*M.cephalus*	*L. saliens*	*L. aurata*
1956/1957	67.57	32.43	0.0
1957/1958	100.00	0.0	0.0
1958/1959	100.00	0.0	0.0
1959/1960	97.32	2.68	0.0
1960/1961	100.00	0.0	0.0
1961/1962	100.00	0.0	0.0
1962/1963	83.33	16.67	0.0
1963/1964	45.11	54.89	0.0
1964/1965	100.00	0.0	0.0
1965/1966	96.15	3.85	0.0
1966/1967	97.94	2.06	0.0
1967/1968	79.20	20.80	0.0
1968/1969	100.00	0.0	0.0
1969/1970	100.00	0.0	0.0
Average	90.47	9.53	0.0

TABLE 90. Percentage composition between the three species in the catchas from tha see elong the Bulgarien coast (Alexandrova, 1973)

Year	M. cephalus	L. saliens	L. aurata
1966	8.76	9.37	81.87
1967	3.93	34.40	61.67
1968	4.49	10.15	85.36
1969	6.09	9.07	84.84
1970	7.63	44.03	48.34
Average	6.18	21.40	72.42

Mullets ere extremely sensitive to tempereture chenges of the sae, espacially in the north-western part of tha basin where their mortality can raech 90%. After the wintering period, they enter the near shore firths whera thay feed till the end of Octobar. When the temperature suddenly drops in the month mentioned they usuelly cannot leeve these ereas and mess mortelity occurs.

The young individuels forege on zooplenkton, and adults on detritus and larvae of mussels. Tha meximum ege of the goldan mullet is 10-11 yaars. The growth rates in langth end weight wera established using von Bertelanffy's equetions. For this purpose YugNIRO and Alexendrova's date (1964) for the mean langth and weight by aga ware usad. The parametars in the mentioned equations are as follows:

YugNIRO data	YugNIRO data	Alaxandrova (1964)
$L_{\infty} = 70.2$	$W_{\infty} = 2235.4$	$L_{\infty} = 54.98$
$k = 0.0801$	$k = 0.1004$	$k = 0.3005$
$t_0 = -1.0199$	$t_0 = -0.8627$	$t_0 = -0.0316$
	$n = 2.9069$	
	$a = 0.0144$	

On the besis of the velues obteined for k, n and t_0 having in mind the age at sexual maturity, the mean value of the natural mortality coefficient (M) was determined by means of Kutty and Quesim's (1973) and Rikhtar and Efanov's (1976) equations (**Figure 29**). It cen be seen from this figure that according to Kutty and Quasim's method the mean M is 0.45 (t_c = 4.11 years; t_r = 4 years). This equation offarad by Kutty end Quasim (1965) includas tha growth paramaters of von Bartelanffy equations (n, k, t_0)

$$t_c = \frac{\ln(n.k + M) - \ln M}{k} + t_0$$

Hence, if the value of t_c (from Bavarton, Holt aquetion, 1957) we can calculate the mean value of M. Theoretically, t_c must be biggar then t_r. So, if we know the velue of t_r we cen essume thet the value of t_c is somewhat higher than t_r. Following Rikhter and Efanov's method, M is 0.40-0.41. On this account the valua M = 0.425 is used later on.

In **Table 91** tha catch age composition of tha golden mullet during the period 1967-1990 is presented. The age composition wes estimated on the basis of the YugNIRO data for the Crimean-Caucasian stock.

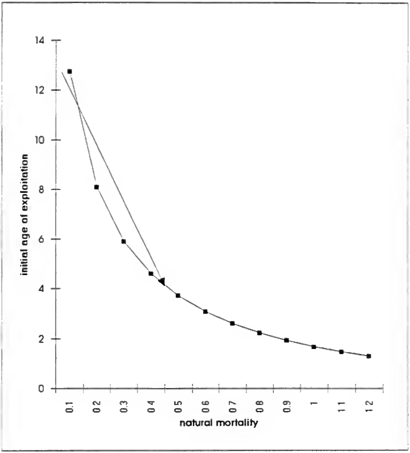


FIGURE 29. Estimating the value of the golden mullet's natural mortality coefficient according to Kutty and Quasim's method

TABLE 91. Age composition in numbers (x 10^{-3}) of golden mullet in the former USSR catches during 1967-1992

Years	1	2	3	4	5	6
1967	0.0	109.3	3115.8	419.1	0.0	0.0
1968	0.0	197.6	905.2	1112.5	139.1	75.6
1989	0.0	41.5	448.3	434.8	144.8	41.5
1970	0.1	130.1	118.2	232.0	152.2	219.1
1971	0.0	115.9	151.3	62.9	53.8	56.5
1972	51.8	254.8	500.1	216.9	58.7	40.9
1973	239.9	2253.2	468.9	132.9	51.9	42.2
1974	5.2	461.7	767.8	277.0	187.8	134.9
1975	423.7	1242.6	1160.5	782.6	118.3	40.1
1978	5 8	764.4	1515.9	337.5	188.9	50.5
1977	1.0	376.9	832.6	517.4	146.5	122.3
1978	0.0	236.5	585.8	202.4	52.3	14.9
1979	146.7	2925.2	584.8	385.6	70.2	22.7
1980	26.7	692.1	849.1	319.0	75.1	8.5
1981	43.9	1141.2	1400.1	526.0	123.7	14.0
1982	40.1	1041.1	1277.3	479.9	112.9	12.8
1983	49.5	1285.1	1578.6	592.3	139.4	15.8
1984	49.0	2102.9	2881.5	1030.0	55.2	6.1
1985	63.6	357.6	1168.2	699.4	349.7	10.8
1988	17.3	2241.0	924.0	949.9	138.2	34.5
1987	18.6	158.0	890.7	331.5	133.2	12.4
1988	32.4	773.3	746.6	240.0	88.7	21.0
1989	120.8	309.8	170.3	54.7	8.7	1.3
1990	11.4	25.2	217.5	45.4	15.8	0.0
1991	34.1	88.5	100.2	25.9	6.3	0.7
1992	33.9	84.8	86.8	37.9	5.3	0.8

Table 91 - continued

Years	7	8	9	10	11	C_N
1967	0.0	0.0	0.0	0.0	0.0	3644.2
1968	9.8	0.0	0.0	0.0	0.0	2439.8
1969	9.8	1.1	0.0	0.0	0.0	1120.7
1970	55.8	12.5	2.3	1.4	0.0	922.6
1971	60.2	17.1	4.8	6.4	4.0	532.9
1972	35.0	21.3	7.5	0.8	1.2	1185.2
1973	25.9	19.5	4.9	3.2	2.0	3242.5
1974	64.3	120.4	40.5	13.5	2.0	2075.1
1975	42.0	3.8	1.9	1.9	0.0	3817.5
1976	11.5	4.3	1.4	1.1	2 5	2884.7
1977	17.2	3.0	1.0	1.0	2.0	2020.9
1978	7.7	0.6	0.0	0.0	0.0	1100.0
1979	8.3	4.1	2.1	2.1	0.0	4131.6
1980	2.8	1.0	0.8	0.4	0.0	1975.2
1981	4.5	1.6	1.3	0.6	0.0	3256.7
1982	4.2	1.4	1.2	0.6	0.0	2971.2
1983	5.1	1.8	1.5	0.7	0.0	3667.5
1984	6.1	0.0	0.0	0.0	0.0	6130.8
1985	2.6	2.6	2.6	2.6	0.0	2649.1
1986	4 3	4.3	4.3	0.0	0.0	4317.9
1987	1.5	1.5	1.5	0.0	0.0	1549.0
1988	15.2	5.7	1.9	1.9	0.0	1904.8
1989	1.3	0.7	0.0	0.0	0.0	667.7
1990	0.0	0.0	0.0	0.0	0.0	315.3
1991	0.1	0.0	0.0	0.0	0.0	253.8
1992	0.1	0.0	0.0	0.0	0.0	249.4

The VPA results with *ad hoc* tuning of the F_{ST} values for the oldest age groups are presented in **Figure 30**. It is seen that the total golden mullet biomass (B1+) from the Crimean-Caucasian stock during the period 1967-1992 has varied between 54.5 (1991) and 1354.5 tonnes (1967) and the spawning biomass - between 9.2 (1991) and 356.5 tonnes (1967). The variations in these biomasses are determined by the year class strength, that varied from 0.658 x 10^6 (1990) to 14.193 x 10^6 (1982) specimens. The year classes of 1981 (13.517 x 10^6), 1972 (12.496 x 10^6) and 1978 (10.076 x 10^6) were also strong, and these of 1991 (0.717 x 10^6), 1989 (0.741 x 10^6), 1988 (1.368 x 10^6) and 1992 (1.902 x 10^6) were weak. The fluctuations in the total and spawning biomass are determined not only by the strength of the different year classes, but also by the fishing mortality rate that is highest during 1988, 1989 and 1974. As a result, the golden mullet biomass has sharply declined. At present, the recommendation of YugNIRO colleagues is that this species not to be fished for a few years. According to their estimates by cohort analysis (1993 annual report of YugNIRO) the golden mullet abundance during the period 1989-1993 has been the following:

Abundence (x 10^{-6})	1989	1990	1991	1992	1993	Averege
N1+	2.3682	1.4618	0.8924	0.6437	0.4736	1.1679
N4+	0.0063	0.0880	0.3148	0.4933	0.3401	0.2485
*	2.0265	1.4395	1.4299	2.6371	2.4379	1.9942
**	0.1092	0.0892	0.0698	0.0868	0.0895	0.0889

* and ** - our estimates for N1+ and N4+

It can be seen from the last table that according to our estimates the total stock abundance (N1+) is higher by 70% on average than that estimated by YugNIRO colleagues, while that of the spawning stock is lower, by an average of 2.8 fold (0.2485 x 10^6 and 0.0889 x 10^6). These differences are due to the different estimates of fishing mortality of 1-3 year old fish. The golden mullet catch of the former USSR in the near shore lakes is based on the biological peculiarities of age 0+ (1) year old fish that enter the lakes in the next spring and leave them by the end of October, i.e. at age 1+, then being subjected to commercial fishery. Based on this assumption F values varied between 0.0215 and 0.2213, averaging 0.0650.

For ages 2 and 3, the mean F values are 0.2393 and 0.8028 respectively. The latter figure is rather high, but one must bear in mind that until sexual maturity is reached, a large proportion of these age groups enter the Sea of Azov for feeding (May-September) and leave it usually early in October. In the course of these migrations through the Kertch Strait the species is fished very successfully, even at low biomass levels. That is why the temporary suspension of the fishery would promote the more rapid recovery of its stock. Taking into consideration the catches of Turkey and the remaining Black Sea countries, one may suppose that, at present, the total species biomass in the Black Sea does not exceed 10 000 tonnes.

One of the major reasons for the stock decline of all mullets including the golden mullet, are the deteriorated conditions of life both in the near shore lakes and in the Black Sea.

According to Alexandrova (1973), the mullets inhabiting the Bulgarian coast are related to the western stock that feeds in the bays, river mouths and lakes on the whole western Black Sea coast. After analysing environmental conditions in the Bulgarian lakes, this author pointed out that 1/3 of their total area was already unusable. Subsequently these unsuitable areas increased, resulting in a sharp decline of Bulgarian catches. Following Alexandrova's data (1973) the average mullet catch of Bulgaria during the period 1950-1970 was 192 tonnes: 146 tonnes caught in the lakes (76%) and 46 tonnes (24%) in the Black Sea.

The situation of the near shore lakes in the remaining Black Sea countries is rather similar. This and the deteriorating life conditions in the Black Sea are the major reasons for the present state of mullet stocks.

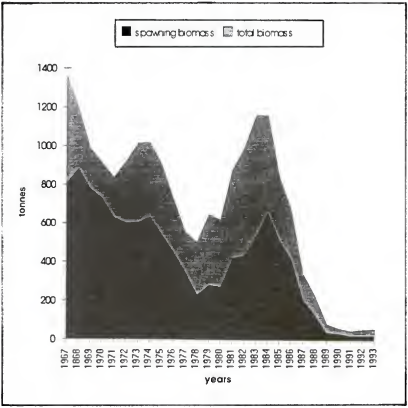


FIGURE 30. Exploited and spawning biomasses (in tonnes) of golden mullet from the Crimean-Caucasian stock during the period 1967-1993

GREY MULLET, *MUGIL CEPHALUS* LINNAEUS

The grey mullet is the most warm-tolerant species and best adapted to lower salinity in the near shore lakes, in comparison to the other mullets. It can also live for a long time in fresh waters.

The grey mullet spawns from the end of May to the middle of August. Its fecundity ranges from 2 to 16 million eggs. The young mullets enter the embayments and river mouths where they may remain up to attainment of sexual maturity . The adults feed primarily in the Sea of Azov, but large numbers occur also in the near shore lakes of the remaining countries. In Turkey, mullet catches in lakes represent around 45-65% of the total mullet catches. In Bulgaria the catch of this species in the Black Sea and lakes represents 42.2% of the total mullet catches.

The rate of growth in length and weight of the grey mullet from the Crimean-Caucasian stock was explored using von Bertalanffy's equations. The parameter values found are as follows:

$L_\infty = 69.5$	$W_\infty = 3539.4$
$k = 0.0881$	$k = 0.0985$
$t_0 = -0.9218$	$t_0 = -0.8153$
	$n = 2.9415$
	$a = 0.0163$

The growth rate of the grey mullet from the Crimean-Caucasian stock, as well as that of the golden mullet, differ significantly from that of the corresponding species from the western stock. According to Alexandrova (1967) the 1+ year old grey mullet attains an average length of 33.47 cm and weights of 388.0 g, and the golden mullet - 17.56 cm and 50 g respectively in the Bulgarian near shore lakes. From Ukrainian data, the grey mullet attains an equivalent length and weight at 6-7 and 5-6 years of age respectively. These differences in relation to the golden mullet are quite smaller. The main reason for the differences may be ageing interpretations that lead to different results on population parameters such as age of sexual maturity, natural mortality rate, etc.

According to YugNIRO data, the grey mullet is not found in great quantities off the coast of the former USSR and is not subject to a specialised fishery. As was pointed out for the near shore lakes of Turkey the grey mullet makes up more than 50% of the total mullet catches. Bearing this in mind we may suppose that at present the grey mullet biomass in the Black Sea does not exceed 5 000-10 000 tonnes.

LEAPING GREY MULLET, *LISA SALIENS* RISSO

As for the golden mullet, the leaping grey mullet prefers waters with higher salinity, hence it rarely enters near shore lekes. Out of the 3 species considered, the leeping grey mullet is most resistant to lowering of the sea weter temperature. The biological characteristics of the mullets hiberneting off the Bulgarian coast are investigated in detail by Alexandrova (1964, 1967, 1973). She showed that tha percantage composition of mullet species during their wintering in Varna bay, Varna and Gebedje lakes was determined mainly by the water salinity. In sea weters (Varna bay) tha laaping grey mullet predominate (98.5%) in wintering concentrations of mullets. In the channel connecting the Sea with the Verna leke, where the salinity is still high, tha seme specias represented 75.9%, while in Varna end Gebedje lakes the proportion of the leeping grey mullet decreased to 37 and 21.4% respectively. The grey mullet was infrequent in the Varna bay (1.5%) while it predomineted in the Gebedje lake.

The leaping gray mullet spewns both in the Black See and Sea of Azov from the end of May to the middle of August. Its fecundity varies between 1 and 2 million eggs. It attains sexual maturity early - the melas at ege 2 (2+ yeer old) end length 21-23 cm, end the females et ege 3 (3+ yaer old) and length 26 cm. According to Alexendrove (1967) 2+ year old fish heve a mean length and weight of 31.2 cm and 277 g respectively. These figures show again that fishery biologists from different Black Sea countries do not always read mullet ages in the same manner.

The leeping grey mullet abundance is not high end specialized fishery is not conducted. In Ukreine it is fished together with the other two species during the migretions to the Sea of Azov, on the way back, and partially on the wintering grounds -from Sevastopol to Gilendjik. According to Alexandrova's data (1973) leaping grey mullet catches both in the Black Sea and tha near shore lekes, averege to 12.5% of mullet catches. Besed on this eccount, its stock in the Black Sea probably does not excaad 5 000 tonnas, i.e. the total mullet biomass (all spacias) presumably is around 20 000-25 000 tonnes.

STING-RAY, *DASYATIS PASTINACA* LINNAEUS

Tha sting-ray is a damarsal fish species. It is oviparous and 3 to 30 eggs develop simultaneously in the uterus. Being e predator, its principal food competitors ere spiny dogfish, turbot, whiting end thornback-ray.

A specialised sting-ray fishery is not cerried out. It appears es by-catch in the pessive gears: trepnets, baach seines, etc.

Teble 92 shows the historical cetch per unit effort.

TABLE 92. Sting-ray catches par unit effort (1 000 hooks) during 1983-1989 (YugNIRO data)

Years	North-eestern part of Black Saa	Crimeen waters	Caucesian region
1983	0.154	0.066	
1984	0.124	0.066	
1985	0.127	0.054	
1986	0.125	0.060	
1987	0.066	0.035	0.091
1988	0.102	0.070	
1989	0.092	0.077	

The sting-rey biomass on the shelf of the northern pert of the Bleck See wes estimeted et 10 000 tonnas (1990). The annual catch on the Ukrainian shelf could reach 1 500-2 000 tonnes, although it has not exceeded 500 tonnes till now (YugNIRO data).

THORNBACK-RAY, *RAJA CLAVATA* LINNAEUS

The thornback-ray is a demarsal predator, feeding on enchovy, horse meckerel, whiting and sprat. Crusteceens are also a major component of its diet although it occasionally also feeds on worms. It is a food competitor with spiny dogfish, turbot, sturgeons, gobies and sting-rays.

Commercially the thornbeck rey is of secondary importance. It makes up to soma extent tha Turkish fishery and also eppeers es e by-catch in the fishery of Ukreine and Russia (**Tabla 93**).

TABLE 93. Ray and skate catches in the Black Sea during 1967-1992 (in tonnes)

Yeer	former USSR	Turkey	Total	Year	former USSR	Turkey	Total
1967	-	1682.6		1980	1100.0	2068.5	3168.5
1968	-	1720.6		1981	1000.0	1147.0	2147.0
1969	-	1512.7		1982	1400.0	1554.0	2954.0
1970	-	835.9		1983	1000.0	3078.0	4078.0
1971	-	2149.4		1984	1200.0	904.0	2104.0
1972	-	1193.3		1985	1100.0	1087.0	2187.0
1973	-	290.3		1986	900.0	797.0	1697.0
1974	-	238.0		1987	400.0	880.0	1280.0
1975	-	51.7		1988	400.0	974.0	1374.0
1976	1200.0	118.9	1318.9	1989	700.0	1254.0	1954.0
1977	1000.0	256.4	1256.4	1990	400.0	633.0	1033.0
1978	1200.0	997.9	2197.9	1991	300.0	778.0	1078.0
1979	1100.0	3390.0	4490.0	1992	100.0	1155.0	1255.0

It is seen from the ebove Teble thet the meen Turkish cetch (1 239.6 tonnes) represent 59.24% ol tha mean total catch (2 092.5 tonnes). Thet of the former USSR is 852.9 tonnes - (40.76%).

It is fished by pessive coestal geers es e sizeeble by-cetch in April-May end in August-Septamber along the south-western Crimeen coest, in the north-eastern part of tha Black See end off the north Caucasian coast.

Eerly in 1990, tha thornback-rey biomass wes estimated et 6 000 tonnes. The assessed optimum catch of 1 000 tonnes has been epproeched for the Ukrainian fishery.

STRIPED MULLET, *MULLUS BARBATUS PONTICUS* ESSIPOV

The striped (red) mullet is a widespread fish species on the Bleck Sea shelf. It is a warm-wetar end commercially valuable fish spacies for tha inshore fishery. Two types of striped mullet exist: "sedentary" and "migratory". The former inhebits primarily the south-eastern pert of the Black Saa (Batumi), meking only local migretions. The second type undertakes migretions in spring to the Kertch Strait, with a considereble portion of its stock antaring the Sea of Azov. In autumn it raturns to its wintering grounds elong the Crimean end northern Caucesien coest.

The mejor pert of the catch is besed on the migretory north Ceucesian stock fished in the area from the Kertch Strait to Adler and in the Sea of Azov. Two peaks in the catchas, in Juna-July end in October-November ere recorded.

During the 1940s end 1950s the migretory striped mullet ebundance wes high, yielding significant annuel catches of 1 600-1 700 tonnas. From tha lete 1960s till now, e sherp decline in the species' biomass occurred elong the former USSR coasts, end the catches dropped to 40-690 tonnes (the former USSR cetches) **(Table 94)**. During the period 1925-1962 Bulgerien catches ranged from 0.0 to 64.0 tonnes (Konstentinov, 1964; Ivanov, 1964).

The strong enthropogenic impect and the outburst of the ctenophore *Mnemiopsis* must in part ba tha causa of week 1988-1991 yeer clesses. In the pest few years the combined biomess of the two types on the former USSR shelf wes estimeted et 1 000 tonnes.

TABLE 94. Striped mullet cetches in the Bleck See during the period 1967-1992 (in tonnes)

Years	former USSR	Turkey	Yeer	former USSR	Turkey
1967	100.0	1625.6	1981	440.0	2047.0
1968	100.0	1148.2	1982	400.0	2436.0
1969	200.0	1547.9	1983	260.0	1915.0
1970	100.0	2203.1	1984	690.0	1812.0
1971	100.0	342.1	1985	100.0	3381.0
1972	100.0	1037.0	1986	420.0	3667.0
1973	-	1161.1	1987	290.0	3528.0
1974	100.0	675.2	1988	150.0	3601.0
1975	200.0	702.7	1989	460.0	5641.0
1976	60.0	611.2	1990	240.0	2344.0
1977	50.0	920.4	1991	60.0	2712.0
1978	150.0	1576.5	1992	40.0	2214.0
1979	210.0	650.3	Averaga	199.2	1973.2
1980	160.0	1803.0	%	9.17	90.83

IV. ENVIRONMENTAL IMPACT ON THE FISH RESOURCES IN THE BLACK SEA

Over 40 ebiotic and biotic peremeters were analysed in an ettempt to establish the factors determining stock fluctuations of commercially valuable fish. The most importent of the biotic factors are predator-prey interrelationships and trophic competitions between the fish species. Among the abiotic ones are environmental elterations induced by natural and enthropogenic causes. The fishing mortality has a direct influence on the most intensively exploited fish stocks, this being the grounds for the extensive and thorough research and discussions of this factor in population dynamics theory. As a result e greet number of models and criteria have been founded for assessing the optimum exploitation level - MSY (meximum sustainable yield), TAC (total allowable catch), "acceptable catch" (DINUMERS), maximum entropy method, harmonic weight method, etc. Notwithstanding, the abundance of certein fish species has frequently diminished disastrously, owing to the complex character of the environmental impact. That is why a number of models, such as PROBUB, DINUMERS (Taivisto and Lavastu, 1989), ECOPATH II (Christensen and Pauly, 1992), etc. have been developed, which consider an ecosystam es a whole, making attempt to ascertain the so called "acceptable catch" for all living organisms subjected to commercial exploitation. For this purpose, for instence using the DINUMERS model, in some cases it has been necessary to find e single solution to more than 200 differential equations that would meet the terms of steady equilibrium of the ecosystem at certain exploitation patterns of the commercielly importent species. This is extramaly herd to do since the interrelations between the species in an ecosystem depend to a great extent on environmental factors. Thesa are incessantly changing under the influance of natural and anthropogenic causes. Some scientists therefore think thet the term "maximum sustainable yield" is devoid of reel sense. Nevertheless, in this respect, an attempt has been made to clarify the principle causes that have brought the fish resources to the present state in the Black Sea.

In Figure 31 the fluctuations in the spawning biomass of anchovy and sprat (B1+) ara shown as well as those of horse mackerel and whiting (B1+). In the same Figure the biomasses of their most ebundant predators - spiny dogfish (B4+) end turbot (B2+) are also presented.

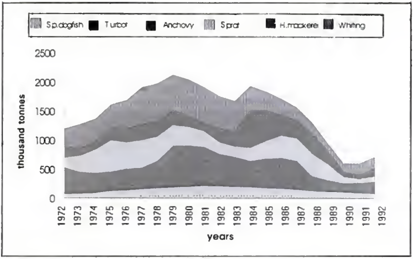


FIGURE 31. Biomasses of spiny dogfish, turbot, anchovy, sprat, horse mackerel and whiting during 1972-1992

The whiting biomass is assessed separately for the eastern and western parts of the basin since the weights by age in the eastern part need specifying (in our opinion these are excessively high for ages over 3 years). For this reason the species biomass in this part of the Black Sea is presumably overestimated. The sprat biomasses assessed relate to the western part of the basin, i.e. they are sizeably greater in the entire basin but since almost no sprat fishery occurs in the eastern part the assessment of sprat biomass by VPA in this region is not possible.

Figure 32 shows the year class abundance of the last four species, the anchovy and sprat being prey to the rest, the horse mackerel and whiting however being predators on the former, but also prey to dogfish and turbot.

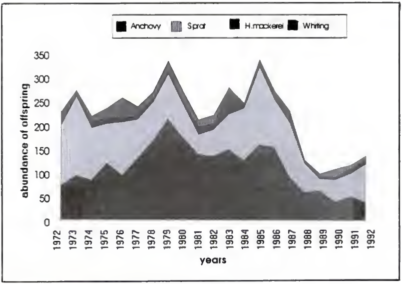


FIGURE 32. Year class abundance in numbers ($x10^{-9}$) of anchovy, sprat, horse mackerel and whiting during 1972-1992

It is seen from the above Figure that in the early 1970s the sums of the mentioned biomasses of the 4 species were around 1 200-1 300 thousand tonnes, but at the end (1978-1980) they were 2 039-2 193 thousand tonnes; i.e. they had increased on average by 69.3%. In the beginning of this period their combined catch ranged from 189.8 to 197.0 thousand tonnes: $U = Y/B = 0.1497 - 0.1534$. By the end of the 1970s, together with the combined biomass rise, increase in catches also occurred. During these years, catches reached 483.4 and 575.1 thousand tonnes, respectively - $U = 0.2204\text{-}0.2725$. After 1980, their combined biomass began to decline, with only insignificant increases in 1984 and 1985. However, the catches continued to rise, reaching their maximum in 1986 and 1987: 622.5 ($U = 0.3522$) and 666.0 ($U = 0.4126$) thousand tonnes respectively. Given mean values of the natural mortality coefficient of the order of 0.45 (horse mackerel) - 0.95 (sprat) this means that the fishing mortality coefficient has varied between 0.65 and 0.80 on average for the 4 species. In 1988 *F* approached its maximum value with a mean of 0.87 ($U = 0.4343$). Negative changes in the ecosystem have simultaneously occurred - frequent phytoplankton blooms causing in some cases mass mortality of bottom and near bottom fish, pollution has increased in the basin, with various chemical compounds - heavy metals, chlor-organic compounds, pesticides, etc. The organic surplus and the heavy fishery, coupled with specific population parameters of the ctenophore, *Mnemiopsis leidyi*, led to its outburst, and resulted in a sharp decline of the small zooplankton (Copepoda) biomass, especially in summer, which acts still more negatively on the fish population.

As is saen from Figure 32, the combined abundance of offspring dacraased staadily in 1988 to 130.4 x 10^9 specimens. During tha next few years (1989-1992) these varied betwean 100.8 x 10^9 (1989) and 140.2 x 10^9 number of spacimans. On this account tha combined biomass of the 4 species remained low - between 625.3 (1991) and 774.3 thousand tonnes (1992).

Tha fishing mortelity impact on the combined biomass of thesa 4 spacias has baen axplored by means of the following functions:

(20) $B = a*U*\exp[-(b*U)]$

(21) $B = a*U*\exp[-(b*U + cB_1)]$

where: B is the combined biomass ; U is exploitation rate (U = Y/B ; Y is combined cetch); B_1 is *Mnamiopsis* biomass in July-August

In Table 95, the parameters of the mentioned equations are presented.

TABLE 95. Parameters of production models for enchovy, spret, horse mackerel and whiting

Parameters	Equation	Equation
a	26081.642	19340.134
b	5.2003417	3.7816159
c		0.0264923
U_{opt}	0.1923	0.2644*
B_{max}	1845.1	1881.2*
r	0.5940	0.8449
D%	35.29	71.39
S%	64.71	28.61

* the values of U_{opt} end B_{max} ere computed et $B_1 = 0$

In the end of the 1970s and early 1980s, the largest biomass was of the jellyfish *Aurelia aurita*. According to Grishin, Covalenko end Sorokolit (in press - personal communication) at thet time tha *Mnamiopsis* outburst was racordad, it had droppad around 15-20 fold. During this period this jellyfish had consumed ebout 60% of the production of nutritious zooplenkton, whila tha anchovy, spret and horsa mackerel hardly usad 6-7% (Shulman end Urdenko, 1989). Consequently up to tha 1980s, the Black Sae trophic base has been under jellyfish control, primarily by *Aurelia aurita*. During this period, the eutrophication of tha basin still has had positive effects on tha palagic fish populations. At prasent, tha ctanophora *Mnemiopsis leidyi* being most abundant has tha decisive importance for the ecosystam whila the biomass of the native jellyfish hes baan greatly raduced. Most fish populations also decreased in biomass; haavy fishing being the other major factor. Fish ara more active predators on zooplankton end with reduced fishing affort, thay could overcoma the unfavoureble trophic conditions. According to aquetion (21), the optimum mean value of ***F*** for the mentioned specias is around 0.45 (U_{opt} = 0.2644) provided the ctenophora biomass is aqual to 0. However, as wes alreedy pointed out, before *Mnamiopsis laidyi* antered tha basin, the dominant species wara tha jallyfish and the native ctenophore *Pleurobrachia pilleus*. After 1990, tha coefficiant of axploitation was considerebly lowered which was the major raason for tha obsarved trend toward incraasa of tha enchovy, spret and whiting stocks. The fishing mortelity impact is still better expressed in the cese of the Azov anchovy. Its biomass hes recovered after temporery cessation of the fishery, elthough the *Mnamiopsis* biomass in the Saa of Azov continues to be rather high.

The remaining ebiotic end biotic factors also axart substential influenca on the fish population abundance. In Tabla 96 is presented e correletion matrix that raflects the impact of 42 environmental paramaters. It is seen that thera is e cleer trend towards a decline in tha quantity of silicon, both in the eastern (r = -0.930) and western parts of tha Black Saa (r = -0.862). As it is well-known the silicon is one of the basic elements in tha cell structure formation of dietoms (Bacilleriophyta). This established relationship is very important, since so far, the decline in tha biomess of these elgae has baen releted only to variations in soler activity (Petrova-Karadjova and

Apostolov, 1988). The next in reliability is the trend towards a decrease of the biomass of the jellyfish *Aurelia aurita*, especially in the eastern part of the basin (r = -0.882). The trend to the aggravation of the oxygen regime in the Black Sea is well expressed too. The self-purifying capability of the basin, especially in its western part, has declined with time (r = -0.659). The correlation coefficients between the latter, on the one hand, and the oxygen concentration and the phytoplankton biomass on the other, are 0.675 and -0.540 respectively. The interrelationship between the oxygen concentration in the near bottom layers and the phytoplankton biomass is also negative.

The zooplankton biomass in the western part of the Black Sea also shows a tendency to decline, particularly in summer (r = -0.729). As regards fish, the trend towards a decline of the turbot exploited biomass is well expressed (r = -0.668).

On the basis of these interrelationships between the biotic and abiotic environmental parameters, a multi-factorial correlation analysis was performed to establish the most significant factors determining fish species abundance. For this purpose, linear, parabolic and exponential functions were applied.

According to the parameter values in the linear equations used, the abundance of anchovy offspring is positive related to the total phosphorus concentration, the amount of river inflow and the phytoplankton biomass in the eastern part of the Black Sea, and negatively related to the sea water temperature (according to data for the temperature in the Odessa bay), to the phytoplankton biomass in the western part of the basin, and to the zooplankton biomass in the whole Black Sea (Table 97). The last one is due to the fact that the zooplankton biomass is defined residual, i.e. its concentration (mg/l) depends on the abundance of its predators, including that of the anchovy, the latter being typical zooplanktivores. The reliability of the established relationship is extremely high: 99.9%.

The effect of the most abundant fish species on the strength of the anchovy year classes is shown in Table 98. It is seen that the abundance of the year classes is directly proportional to the anchovy spawning biomass (B1 +), to the strength of the year classes of horse mackeral, sprat and whiting in the western part of the basin, to the biomasses of horse mackeral (B1 +), sprat (B1 +), turbot (B2 +) and of whiting (B1 +) in the western part, and inversely proportional to the spiny dogfish biomass (B4 +), and to the year class strength and biomass of whiting in the eastern part of the basin. In this case the correlation coefficient approaches 0.9594, which shows that the equation fits precisely VPA data for the stock size of the mentioned fish species.

The equations derived show that when including each new member, reflecting the influence of the relevant factor, the values of the parameters at the independent variables change constantly, inclusive from positive to negative in spiny dogfish and whiting from the eastern part of the basin. Both species are predators of the anchovy, especially in winter during the wintering of the latter off the Anatolian coast of Turkey and also off the Caucasian coast.

TABLE 96. Correlation matrix of environmental and fish stock data, year Y-1, Y

	Correlation matrix of environmental and fish stock data, year Y-1,Y														NWBS							
		year	Odessa	T Batumi	W h	Wspeed	W3	Sflux	Npress	C W	Rinf	RinfNW	RF	Ptot	O2	Si	PO4	AC	Ph	Noc	Zoo	ZooPro	Pleuro
	year	1.000																					
	T Odessa	-0.270	1.000																				
	T Batumi	0.639	0.607	1.000																			
	W h	0.164	0.473	0.352	1.000																		
	Wspeed	-0.402	0.547	0.355	0.157	1.000																	
	W3	-0.426	0.521	0.349	0.136	0.997	1.000																
	Sflux	0.144	0.102	-0.107	0.315	-0.237	-0.256	1.000															
	Npress	-0.276	-0.183	0.182	0.350	0.205	0.226	-0.847	1.000														
	C W	0.095	0.221	-0.044	0.317	-0.230	-0.240	-0.261	0.242	1.000													
	Rinf	0.227	-0.058	-0.010	0.275	-0.743	-0.748	0.389	0.064	-0.109	1.000												
	RinfNW	0.163	0.033	0.038	0.166	-0.478	-0.502	0.323	0.009	-0.101	0.992	1.000											
	RF	0.014	0.166	0.083	-0.067	-0.233	-0.240	0.235	-0.051	-0.150	0.585	0.582	1.000										
	Ptot	0.739	-0.160	-0.481	0.282	-0.664	-0.673	0.647	-0.841	-0.116	0.446	0.377	0.360	1.000									
	O2	0.611	0.301	0.366	0.027	0.602	0.604	-0.198	-0.038	0.230	-0.508	-0.526	-0.153	-0.715	1.000								
NWBS	Si	-0.862	0.441	0.513	0.219	0.298	0.278	-0.110	0.065	0.023	-0.177	-0.135	0.036	-0.416	0.632	1.000							
	PO4	0.023	0.198	0.086	0.063	0.704	0.725	-0.223	0.249	-0.257	-0.094	-0.024	-0.242	0.397	0.004	-0.206	1.000						
	AC	-0.659	0.142	0.198	-0.396	0.302	0.311	0.407	0.043	0.320	-0.396	-0.405	-0.229	-0.360	0.675	0.735	-0.265	1.000					
	Ph	0.358	-0.030	-0.245	-0.014	0.004	0.024	0.092	0.046	-0.210	0.279	0.305	0.233	0.279	-0.641	-0.264	0.159	-0.540	1.000				
	Noc	0.523	0.619	-0.267	0.269	-0.513	-0.503	-0.184	0.027	0.376	0.227	-0.013	-0.210	0.321	-0.400	-0.383	-0.242	0.128	0.168	1.000			
	Zoo	-0.729	0.461	0.518	0.241	0.025	0.058	0.067	-0.051	0.111	0.125	0.115	0.398	0.075	0.564	0.582	0.010	0.376	0.097	-0.231	1.000		
	ZooPro	-0.164	0.525	0.134	0.287	0.538	0.531	-0.113	-0.291	-0.287	-0.420	-0.363	-0.361	0.111	0.599	0.002	0.262	0.327	-0.380	-0.295	-0.198	1.000	
	Pleuro	0.228	-0.149	-0.227	0.191	0.875	0.891	-0.257	0.289	0.157	-0.349	-0.332	-0.462	-0.617	-0.109	-0.278	0.401	-0.078	0.101	-0.130	-0.464	0.279	1.000
FBS	Si	-0.930	0.478	0.563	0.053	0.804	0.803	-0.074	0.003	0.042	-0.253	-0.214	0.083	-0.732	0.749	0.970	-0.119	0.753	-0.323	-0.369	0.671	-0.083	-0.307
	PO4	0.620	0.015	0.156	-0.171	0.235	0.234	0.336	-0.237	0.012	-0.108	-0.140	-0.061	-0.671	0.513	0.484	-0.074	0.465	0.380	-0.148	0.169	-0.351	0.068
	Ph	0.574	-0.347	-0.428	-0.465	-0.423	-0.446	0.209	-0.104	-0.179	0.229	0.225	0.087	0.483	-0.602	-0.524	-0.112	-0.589	0.407	-0.033	-0.575	0.297	-0.010
	Noc	0.161	0.091	-0.064	0.266	-0.317	-0.339	0.246	-0.386	0.123	0.191	0.155	0.085	0.373	-0.147	-0.114	-0.262	0.104	-0.060	0.024	-0.043	0.388	0.197
	Zoo	0.151	0.195	0.039	0.323	0.476	0.512	0.101	0.035	-0.018	0.217	0.222	0.389	-0.140	-0.077	-0.368	0.301	-0.255	0.132	-0.158	0.210	0.092	0.265
	Copepod	0.198	0.018	-0.066	0.050	0.277	0.309	-0.037	0.099	0.042	0.167	0.140	0.282	-0.140	0.044	-0.279	0.140	-0.101	-0.054	-0.288	0.154	0.178	0.201
	Pleuro	0.484	-0.471	-0.359	-0.598	-0.006	-0.014	-0.279	0.412	0.078	-0.068	-0.053	-0.076	-0.470	-0.449	-0.537	0.009	-0.324	0.272	0.063	-0.656	-0.360	0.401
	Aurelia	-0.882	0.089	-0.137	0.088	-0.055	-0.080	0.028	0.107	0.154	0.920	0.819	0.790	0.455	-0.095	0.752	0.885	-0.747	0.656	-0.838	0.567	0.573	0.254
	SpR	0.423	-0.348	-0.462	-0.041	0.484	0.499	-0.050	0.026	0.038	-0.296	-0.330	-0.362	0.565	0.110	-0.502	0.108	-0.093	0.099	0.235	-0.478	0.003	0.750
	SpB1+	0.458	-0.448	-0.369	-0.327	0.034	0.059	-0.262	0.260	-0.184	-0.051	-0.060	-0.222	-0.253	-0.307	-0.638	0.379	-0.551	0.414	0.243	-0.550	-0.247	0.348
	SpN1+	0.410	-0.373	-0.427	-0.157	0.329	0.362	0.139	0.131	-0.050	-0.282	-0.318	-0.218	-0.635	0.004	-0.569	0.253	-0.338	0.130	0.213	0.346	-0.216	0.599
	WhR	-0.351	0.044	0.156	-0.029	-0.162	-0.167	0.106	0.056	-0.049	0.620	0.668	0.120	0.322	-0.294	0.042	0.069	-0.424	0.336	-0.280	0.207	0.178	-0.256
	WhB1+	-0.619	-0.098	-0.040	-0.178	-0.219	-0.208	-0.034	0.210	-0.063	0.341	0.310	0.527	0.417	-0.595	0.594	-0.504	0.000	0.344	-0.278	0.264	0.011	-0.226
	HmR	0.266	-0.105	-0.277	0.115	0.199	0.193	0.044	-0.150	-0.236	-0.037	-0.066	-0.093	0.393	-0.245	-0.326	0.084	-0.324	0.046	0.165	-0.214	0.509	-0.103
	HmB2+	0.602	-0.589	-0.436	0.086	-0.465	-0.440	-0.218	0.167	0.228	-0.019	-0.098	-0.160	0.066	-0.563	-0.680	-0.136	-0.362	0.125	0.711	-0.552	-0.469	0.344
	AnR	-0.226	-0.282	-0.143	0.092	-0.274	-0.258	0.124	0.250	0.004	0.279	0.238	-0.043	0.545	-0.824	-0.268	-0.167	-0.527	0.483	0.249	-0.033	-0.323	-0.118
	AnB1+	0.443	-0.219	-0.063	-0.059	0.269	-0.254	0.002	0.188	0.044	0.535	0.465	0.256	0.626	-0.748	0.036	-0.349	-0.362	0.423	0.167	0.273	-0.346	-0.243
	MacB1+	0.049	0.034	-0.006				0.640	0.336	0.502	-0.496	-0.461	-0.446		0.346	0.702	-0.531	0.819	0.788	0.448	0.087		0.267
	DfB8+	0.008	0.311	-0.504	0.003	-0.599	-0.602	0.116	-0.106	-0.178	0.595	0.551	0.370	0.896	-0.827	-0.275	0.415	0.347	0.339	0.269	0.093	0.005	-0.636
	Tur2+	-0.668	0.471	0.476	-0.005	0.117	0.100	0.438	0.023	0.239	0.611	0.637	0.458	-0.129	-0.230	0.627	0.068	-0.527	0.526	-0.715	0.338	-0.029	-0.129

Table 96 - continued

	Correlation matrix of environmental and fish stock data, year Y-1,Y	EBS																			
		Si	PO4	Ph	Noc	Zoo	opepod	Pleuro	Aurelia	SpR	SpB1+	SpN1+	WhR	WhB1+	HmR	HmB2+	AnR	AnB1+	MacB1+	DIB8+	Tur2+
	year																				
	T Odessa																				
	T Batumi																				
	W h																				
	Wspeed																				
	W3																				
	Sflux																				
	Npress																				
	C W																				
	Rinf																				
	RinfNW																				
	Rf																				
	Ptot																				
	O2																				
NWBS	Si																				
	PO4																				
	AC																				
	Ph																				
	Noc																				
	Zoo																				
	ZooPro																				
	Pleuro																				
EBS	Si	1.000																			
	PO4	0.531	1.000																		
	Ph	-0.642	-0.353	1.000																	
	Noc	-0.180	-0.063	0.099	1.000																
	Zoo	-0.290	-0.302	-0.215	0.182	1.000															
	Copepo	-0.202	-0.335	-0.039	0.304	0.769	1.000														
	Pleuro	-0.563	-0.131	0.517	-0.036	-0.124	0.056	1.000													
	Aurelia	0.482	-0.026	0.649	0.721	0.460	1.000	-0.666	1.000												
	SpR	-0.485	0.041	0.105	0.087	0.026	0.133	0.544	0.071	1.000											
	SpB1+	-0.631	-0.255	0.466	-0.193	-0.205	-0.304	0.601	0.231	0.545	1.000										
	SpN1+	-0.517	-0.107	0.116	-0.090	0.127	-0.061	0.510	0.093	0.827	0.703	1.000									
	WhR	-0.174	-0.107	0.505	0.126	-0.290	-0.608	-0.153	0.758	-0.159	0.341	-0.076	1.000								
	WhB1+	0.195	0.140	0.396	0.318	-0.132	0.034	0.155	0.827	0.203	0.102	0.175	0.378	1.000							
	HmR	-0.361	-0.263	0.393	-0.232	-0.016	0.202	-0.022	0.244	0.085	0.138	0.052	-0.060	0.247	1.000						
	HmB2+	-0.696	-0.327	0.211	0.112	0.024	0.089	0.554	-0.202	0.568	0.605	0.626	-0.147	0.195	0.117	1.000					
	AnR	-0.431	-0.266	0.379	0.060	0.533	0.733	0.156	0.660	0.159	0.413	0.233	0.552	0.729	0.192	0.402	1.000				
	AnB1+	-0.176	-0.031	0.191	0.112	-0.239	-0.381	-0.032	0.773	0.080	0.157	0.153	0.528	0.871	0.149	0.269	0.885	1.000			
	MacB1+	0.842	-0.193	-0.629	0.017	-0.573	-0.144	0.528		-0.114	0.240	-0.273			-0.025	0.072	1.000	-1.000	1.000		
	DIB8+	-0.729	-0.591	0.548	0.374	-0.406	-0.384	-0.179	0.786	-0.157	0.192	-0.091	0.564	0.675	0.306	0.248	0.804	0.798		1.000	
	Tur2+	0.462	0.368	0.351	-0.167	-0.106	-0.710	0.186	0.940	-0.322	0.015	-0.332	0.574	0.526	-0.111	-0.588	0.308	0.424		0.107	1.000

TABLE 97. Multiple regression analyses of Anchovy recruitment (indep. varieble) and environmental data

Multiple regression analyses of Anchovy recruitment(indep. variable) and environmental data

Regression Statistics

Multiple R	0.9635
R Square	0.9283
Adjusted R Square	0.8669
Standard Error	9.6565
Observations	14

Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regressio	6	8452.3	1408.7	15.107	0.0011
Residual	7	652.73	93.247		
Total	13	9105			

	Coefficie	Standard Error	t Statistic	P-value	Lower 95	Upper 95%
Intercept	131.5	37.004	3.5537	0.0035	44.002	219
T Odessa	-8.267	3.0204	-2.737	0.017	-15.41	-1.125
Plat	0.6382	0.1145	5.5716	9E-05	0.3674	0.9091
Rinf	0.145	0.0768	1.8869	0.0817	-0.037	0.3267
Ph	0,0244	0.0059	4.1413	0.0012	0.0104	0.0383
Ph	-0.047	0.0087	-5.407	0.0001	-0.068	0.027
Zoo	-0.473	0.0922	-5.123	0.0002	-0.691	-0.254

Regression Statistics

Multiple R	0.9478
R Square	0.8983
Adjusted R Square	0.8192
Standard Error	11.656
Observations	17

Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regress	7	10801	1543	11.357	0.0008
Residuc	9	1222.8	135.86		
Total	16	12024			

	Coefficie	Standard Error	t Statistic	P-value	Lower 95	Upper 95%
Intercep	-173.6	58.176	-2.984	0.0088	-305.2	-42.02
T Odess	9.8311	4.2229	2.328	0.0334	0.2782	19.384
SpR	0.2193	0.1465	1.4974	0.1538	-0.112	0.5507
WhB1+	-0.295	0.1656	-1.779	0.0942	-0.669	0.0799
tIm82+	0.112	0.045	2.4913	0.0241	0.0103	0.2138
An81+	0.0593	0.0333	1.7781	0.0944	-0.016	0.1347
DfB8+	0.5491	0.1547	3.5481	0.0027	0.199	0.8991
Tur2+	1.8742	0.6417	2.9205	0.01	0.4225	3.3259

TABLE 9B. Parameter values in the multiple correlation, reflactingthe reletionships between anchovy recruitment and the stocks of the most abundant fishes in the Bleck Sea

Para-meters	R = f(B)	R = f(B,B1)	R = f(B,B1, B2)	R = f(B,...R2)	R = f(B,...B3)	R = f(B,...B4)
a	18.1208	0.7997	-1.1952	1.2233	-43.4978	-32.8737
b	0.2343	0.1491	0.1546	0.1458	0.2263	0.2766
c		0.3493	0.3289	0.3778	-0.2685	-0.3855
d			0.0096	-0.0006	0.1515	0.1737
e				-0.3157	0.4763	0.7243
f					0.2005	0.2416
g						-02343
r	0.7512	0.8103	0.8107	0.8145	0.8623	0.8947
D%	56.43	65.66	65.72	66.34	74.36	80.05
S%	43.57	34.34	34.28	33.66	25.64	19.95

Table 98 - continued

Pere-meters	R = f(B....B5)	R = f(B,...R5)	R = f(B,...R3)	B = f(B,...R4)	B = f(B,...B6)
e	-89.4231	-107.4902	-116.0028	-186.4526	-244.5723
b	0.2712	0.2400	0.2587	0.2827	0.2255
c	-0.3070	-0.1182	-0.2677	-0.5977	-0.0602
d	0.1623	0.1250	0.1333	0.1638	0.1612
e	0.6941	0.5775	0.4946	0.8130	0.7894
f	0.1782	0.1557	0.1568	0.0229	-0.2254
g	0.0031	0.0296	0.1683	0.7148	0.5052
h	0.0913	0.0997	0.1404	0.2727	0.2801
i		0.1344	0.0975	0.0091	0.1768
j			-1.0702	-2.2406	-29920
k				3.9739	2.6217
l					6.0629
r	0.9220	0.9246	0.9301	0.9439	0.9594
D%	85.01	85.49	86.51	89.09	92.04
S%	14.99	14.51	13.49	10.91	7.96

R end B are the ebundance of recruitment ($x10^{9}$) and spawning biomass odf anchovy (in tonnes x 10^{-3}) respectively; B_1 - spiny dogfish biomass (B4 in tonnes x 10^{-3}); B_2 - horse mackerel biomess (B1+ in tonnes x 10^{-3}); R_2 - horse mackerel recruitment (N x 10^{-9}); B_3 - whiting biomess in the eastern part of the Black Sea (B1+ in tonnes x 10^{-3}); B_4 - whiting biomess in the western part of the Black Sea (B1+ in tonnes x 10^{-3}); B_5 - sprat biomass (B1+ in tonnes x 10^{-3}); R_5 - sprat recruitment (N x 10^{9}); R_3 - whiting recruitment in the eastern part of the basin (N x 10^{-9}); R_4 - whiting recruitment in western pert of the basin (N x 10^{9}); B_6 - turbot biomass (B2+ in tonnes x 10^{-3}).

The stock-recruitment relationship was explored using Ricker and Ivanov's equations. The correlation coefficients are 0.8070 and 0.8102 respectively. Hence, the multi-factorial correlation analysis describes more precisely the VPA results, since by this analysis the complex influence of different biotic and abiotic factors can be established, as well as the influence of the 6 most abundant fish species in the Black Sea. The latter are connected with various interrelations -from competition for food resources to rapacity of some species in relation to other species. Since the equation reflects the interrelationships between the 6 fish species unambiguously it shows that the component part of the ecosystem at each state of the environment aspires to a finite state of balance. Therefore, when the trophic conditions in the Black Sea deteriorated after the *Mnemiopsis* outburst, the biomass of fish species sharply declined (Figure 31). The impact of the remaining factors is less significant, although in particular years they may be the determining factor for offspring abundance of a fish species.

In Table 99 are presented the parameters of the equations reflecting the relationships between sprat offspring abundance and some environmental factors. As it is apparent from this Table, the values of "*r*" do not exceed 0.712, which suggests a weak dependence of the offspring abundance on the investigated factors, since the influence of random variation does not decrease below 49.3%.

In Table 100 are presented the values of the parameters of the equations reflecting the relationships between sprat offspring abundance along the Bulgarian coast and its spawning biomass (B1+), the fishing mortality rate (F), the duration (X1 and X3) and the average speed of winds with a western component (X2 and X4) during November-December and January-March, the intensity of cosmic rays (X5) and solar activity (X6). As it is evident from the table, the coefficient "*r*" reaches the value 0.869 which means that the influence of random factors is 24.53%. Among the examined variables the western wind speed during November-December and January-March proves to be of greatest significance, i.e. when the sprat is intensively spawning at depths of 25-100 m. It is well known that winds with a westerly component impose an upwelling of deep waters and displaces them shorewards. As these waters are rich in nutrients during the summer months, they could contribute a lot to phytoplankton bloom initiation. Because of their low temperature and low oxygen content, they could be responsible for regional zoobenthic mortality as well as fish species. As these water masses contain hydrogen sulphide, it may be hypothesised that indirectly they could also contribute to the mortality events. In winter, similar upwelling of deep waters take place, but unlike in summer their temperature is higher than that at the surface.

TABLE 99. Parameter values of equations reflecting the relationships between the abundance of sprat fingerlings and some environmental factors

Parameters	R=f(B)	R=f(B,.. X1)	R=f(B,.. X2)	R=f(B,.. Z)	R=f(B,.. X3)	R=f(b,.. X4)	R=f(B,.. X5)	R=f(B,.. X6)
a								
b	0.06847	0.07213	0.05075	0.06702	-0.06473	-0.08325	-0.03402	-0.11140
c		-0.00731	-0.00459	-0.00434	0.04437	0.04914	0.05284	0.03108
d			-0.22171	-0.32742	-0.30074	-0.44648	-0.45368	-0.27971
e				-32.6592	-24.0001	-28.5162	-27.0093	-25.3243
f					-1.30726	-1.22958	-1.67992	-1.36845
g						-3.67857	-5.60691	-5.67867
h							-0.12479	-0.14030
i								-190.6102
r	0.137	0.144	0.207	0.323	0.667	0.683	0.687	0.712
D%	1.88	2.07	4.29	10.44	44.49	46.65	47.20	50.70
S%	98.02	97.93	95.71	89.56	55.51	53.35	52.80	49.30

R is abundance of sprat fingerlings (N x 10^{-9}); B - sprat spawning biomass (B1+); X1 - phytoplankton biomass; X2 - zooplankton biomass; Z - total mortality rate; X3 - sea water temperature; X4 - solar activity; X5 - cosmic ray intensity; X6 - Earth's geomagnetism

TABLE 100. Parameter values in the equations reflecting the relationships between sprat fingerlings along Bulgarian Black Sea coast and the investigated environmental factors

Parameters	R=f(X1)	R=f(X1,.. X2)	R=f(X1,.. X3	R=f(X1,.. X4	R=f(X1,.. 8)	R=f(X1,.. F)	R=f(X1,.. X5)	R=f(X1,.. X6)
a	41.979	-73.012	-55.894	-192.629	-187.076	-152.426	-153.762	75.698
b	-0.0005	-0.0685	-0.0653	-0.02133	-0.0185	-0.0210	-0.0209	-0.0171
c		16.2959	15.5275	8.7793	8.0138	7.9136	7.9090	4.1665
d			-0.0233	-0.0654	-0.0551	-0.0526	-0.0522	-0.0624
e				21.3136	20.1659	17.9572	17.9165	21.6886
f					0.0485	-0.0079	-0.0083	0.0935
g						-39.2660	-39.1342	-14.4874
h							0.0004	-0.0520
i								-0.2607
r	0.107	0.543	0.558	0.843	0.845	0.855	0.855	0.869
D%	1.14	29.46	31.12	71.02	71.41	73.02	73.02	75.47
S%	98.86	70.54	68.88	28.98	28.59	26.98	26.98	24.53

B is the spawning biomass; F the fishing mortality rate; X1 and X3, X2 and X4 are the duration and average speed of winds with a western component during November-December and January-March respectively; X5 is the intensity of cosmic rays; X6 is the solar activity.

As it appears from Table 100, wind velocity has a favourabla affact while its duration is nagativa. Tha integral impact of thasa variablas on tha sprat fingarling abundance is considerable - tha value of "r" is 0.843 (D% = 73.02; S% = 26.98). Tha further complication of tha equation by introducing tha rast of tha variablas doas not rasult in a significant incraase in the value of "*r*" that suggests that tha sprat fingerlings do not dapand to a graat axtant on othar factors. According to Stoyanov (1966) the sprat ganerations and spawning biomass dapend both on tha predator abundance and on the number of days with water temperature below 6°C during November-March. Tha sama author pointed out that tha influanca of water tamperatura is indiract via the food wab. Bryantzav (1990) also showad the great importanca of tha character of the atmospharic circulation during differant years for the productivity of the Black Sea. The same euthor noted thet this relation is better expressed in anchovy and less so in sprat.

Tabla 101 shows the results of multiple correlation analysis including thase factors of major importance for sprat offspring abundance. It is sean that this is directly proportional only to spawning stock size and invarsaly proportional to tha tharmal background in tha Black Saa, to tha river inflow in the western pert of the besin, to the emount of phosphatas, end to tha phyto- and zooplankton biomass.

The relationship betwaen the catchability and sprat stock density was investigated by equation (9). It was established that this is typical of meny gragarious fishes, showing nagative density dependent catchability (Figure 33). The reason for such a relationship is the gregarious behaviour resulting in greater fish availability to the fishary. Tha value of coafficiant "*b*", is closa to -1, showing that tha CPUE is not proportional to tha biomass, but rathar to tha catch (Ulltang, 1980). That means that the CPUE will remain unchangeable whan tha biomass varias. On the other hand, this shows that unchanged fishing effort will give constant catchas with raduction of stock abundanca and will provoka an immediata rise of fishing mortality. This phanomanon was obsarvad in most casas of sprat stock raduction (Figure 15). It was most conspicuous during 1954-1957, when the effort (number of trapnets) was quasi constant.

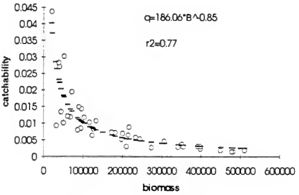


FIGURE 33. Relationship batween catchability and sprat biomass

TABLE 101. Multiple regression analyses of Sprat recruitment (indep.variable) and environmental data

Multiple regression analyses of Sprat recruitment(Indep. variable) and environmental data

Regression Statistics

Multiple R	0.8792
R Square	0.7729
Adjusted R Square	0.7048
Standard Error	24.215
Observations	27

Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regressio	6	39924	6654	11.347	2E-05
Residual	20	11728	586.39		
Total	26	51651			

	Coefficie	Standard Error	t Statistic	P-value	Lower 95	Upper 95%
Intercept	202.75	230.54	0.8794	0.3872	-278.2	683.66
T Batumi	-5.838	13.971	-0.418	0.6795	-34.98	23.304
RinfNW	-0.085	0.1493	-0.567	0.5758	-0.396	0.2268
PO4	-2.379	3.2802	-0.725	0.4748	-9.221	4.4637
Zoo	-0.464	0.1516	-3.061	0.0051	-0.78	-0.148
Ph	-0.038	0.0219	-1.742	0.0933	-0.084	0.0075
SpN1+	0.3934	0.0909	4.3262	0.0002	0.2037	0.5831

Regression Statistics

Multiple R	0.9839
R Square	0.968
Adjusted R Square	0.9361
Standard Error	8.9381
Observations	17

Analysis of Variance

	df	Sum of Squares	Mean Square	F	Significance F
Regress	8	19358	2419.7	30.289	3E-05
Residuc	8	639.11	79.889		
Total	16	19997			

	Coefficie	Standard Error	t Statistic	P-value	Lower 95	Upper 95%
Intercep	-57.28	28.775	-1.991	0.0639	-123.6	9.0788
Ph	-0.02	0.0139	-1.441	0.1689	-0.052	0.012
Zoo	-0.132	0.0899	-1.47	0.1609	-0.34	0.0752
HmB2+	-0.116	0.0429	-2.699	0.0158	-0.215	-0.017
WhR	3.6002	1.1776	3.0572	0.0075	0.8846	6.3159
Wh81+	0.81	0.1281	6.3255	1E-05	0.5147	1.1053
Df88+	-0.148	0.1111	-1.336	0.2001	-0.405	0.1077
Tur2+	-3.344	0.7761	-4.308	0.0005	-5.133	-1.554
SpN1+	0.8561	0.1021	8.3887	3E-07	0.6208	1.0915

In order to study tha avolution of tha stock in ralation to tha exploitation intansity, tha interralation batwean yiald/biomass and fishing mortality was axplorad, assuming stabla reproduction conditions ara mat (i.e. conditions of aquilibrium). As is sean from Figures 34A and 34B, two statas of equilibrium wara differentiated with charactaristic diffarencas in tha modal paramaters (Table 102). For tha first pariod, all tha paramaters were considerably lowar (excapt for r max) than thosa for tha sacond period.

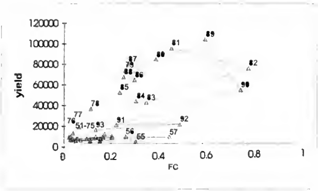


FIGURE 34a. Plot and trajectory of sprat yield on fishing mortality (FC)

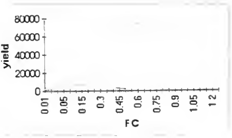


FIGURE 34b. Surplus production curves over periods 1951-1953 and 1974-1990

TABLE 102. Paramatars in the ampirical relationships between biomass, yield and fishing mortality in two periods of assumad aquilibrium

Paramatar	Boo (a)	r max (a/b)	MSY	Fmsy
1951-1973	158966.0	0.64	6010.6	0.164
1974-1990	452113.8	1.00	77334.3	0.629

As is sean, the valuas of MSY and F_{msy} for the two periods differed significantly. In meny cases, the optimum values of F were surpessed during both periods. Concerning the first period, this occurred during 1953-1958, 1964-1965, 1968 and 1972, end in the second period, during 1980, 1981, 1987 and 1989. Aftar the high yield in 1981, the trejectory changed direction from escending to descending (Figure 34A), resulting in e greduel decline of yield end exploitetion level. After 19B3, the ascanding course of tha trejectory changed again showing the recovery of the sprat stock. This continued till 19B9 when the stock ceme out of equilibrium end the coordinetes for 1991 end 1993 became closa to those for 1951-1953.

The enalysis of the stock-racruitment reletionship showed a weak positiva correletion (linear r = 0.533, non-lineer r = 0.60) (Figure 35). The value of the peremeter "c" is 0.88, i.e. very close to 1.0. This parameter determining the type of curva shows that it is near to the Beverton end Holt curve, but with less axpressad protubarance (usuelly an ascendant straight line is obteined when c = 0.5). This curve type more frequently occurs in pelagic fish with a short life span then thet with the exponential (Rickar, 1954) or perabolic (Ivenov, 1977) that involves stronger negetive stock-dependent recruitment (enhenced offspring mortality es a result of cennibelism or interspecies competition).

The low velue of "r" confirms the conclusion that spret offspring abundanca depends on environmantal conditions to a greater extent then on the perent stock siza.

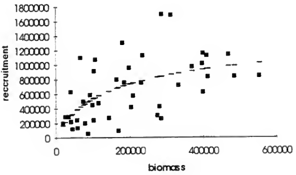


FIGURE 35. Spret stock-recruitment relationship

The impect of fishing mortality rete on the whiting fingerling ebundence is astablished by the followed equations:

(22) $$R = a*B - b*B^2 - c*B*F$$

(23) $$R = a*B - b*B^2 - c*B*F - d*B^2*F$$

The paramatar values of thesa aquetions ere presented in Teble 103. It is evident from tha date that the fishing mortality rate exerts e significant impect on stock-recruitment relationships. The influence of rendom fectors decreesed from 68.09% (according to Ivanov's equation) to 36.6%.

TABLE 103. The parameter values in equations 22 and 23, reflacting the influence of fishing mortality rate on the stock-recruitment relationships of whiting in the western part of tha Black Sea

Equa-tions	a	b	c	d	r	D%	S%	Bopt	Rmax
22	1.1356	0.0041	1.4732		0.771	59.47	40.53	139.8	79.4
23	1.1082	0.0035	0.9109	0.0092	0 796	63.40	36.60	158.0	87.5

In Table 104 results of the multiple corralation analysis era shown, raflecting tha relationship between whiting offspring abundance in the Black Sea and environmental factors. It is apparent that offspring ebundance is diractly proportional to the level of river inflow, and inversely proportionel to phosphate concentration, zooplankton biomass and spawning biomass. The latter probebly is due to tha fact that whiting cannibalism occurs.

It is clear from the above thet the ebundence of the different yeer clesses of the fish species in consideration depends on many and differant abiotic and biotic factors. Determinant for the fish part of the acosystem are the fishing mortality rate and the changes in food wabs, as to the mass davalopmant of *Mnemiopsis leidyi* and the mora frequant phytoplankton blooms provoked by tha eutrophication of the basin.

In anchovy, and partially in horse mackerel and sprat, the first factor is of prime importance for the reduction of thair biomassas. The first two fish spacies reproduce in the summer months in almost the whole Black Saa (Figure 36). During these months the *Mnemiopsis* biomass is highest, and bacause of this its nagative impact is the highest. Besides, this ctanophora inhabits mainly the layars over the thermocline, i.e. tha layers the eggs end lervee of enchovy end horse meckerel ere devaloping in. As previously pointed out, larvaa, although in small quantities, serve as food of *Mnemiopsis leidyi*, thus it exerts e direct influence on species abundance. Tha observed decline in the small zooplankton (Copepoda) in summer months also lowers tha survival of tha lervae end alevins of the two specias. All this ultimately caused the dramatic decline in the anchovy stock in 1990 and 1991. The reduced fishing mortality during the next years is tha major reason for the positive trands towards en increase of its biomass.

The reesons for the depletion of spret biomess in tha western pert of the basin after 1987-1988 elso has e complex charecter. On the one hend, the environmental conditions deteriorated, and on the other the fishing mortality increased. This disproportion inevitably led to the depletion of heavily fished stocks. In such ceses, tha best epproech is to reduce the fishing mortality which would anabla tha ralevant spacias to resist the unfavoureble conditions until their improvemant (Prodanov, 1989). It is seen from Figure 37, that the sprat also spawns in almost the entire Black Sea waters, which allows it to adequately utilise the trophic potentiel of the whole basin. Aftar reducing the fishing effort its stocks also show a rising trand. A similar trend is observed for the stock of whiting and aspacially that of shad. In the case of tha turbot, spiny dogfish, and Russian sturgaon, tha situation is much more complicated since their catchas ara seriously understeted. Furthermore, the regulation measures prohibiting the catch of immature fish, primarily in the casa of turbot and Russian sturgeon, are not observed.

TABLE 104. Multiple regression analyses of Whiting recruitment (indep.variable) and environmental data

Multiple regression analyses of Whiting recruitment(indep. variable) and environmental data

Regression Statistics

Multiple R	0.8511
R Square	0.7243
Adjusted R Square	0.6241
Standard Error	2.2591
Observations	16

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regressio	4	147.51	36.877	7.2255	0.0042
Residual	11	56.141	5.1037		
Total	15	203.65			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*wer 95%*	*pper 95%*
Intercept	-7.6	5.0274	-1.512	0.1514	-18.67	3.465
RinfNW	0.1054	0.0197	5.3434	8E-05	0.062	0.1488
PO4	-0.37	0.4379	-0.844	0.412	-1.333	0.5943
Zoo	-0.055	0.0218	-2.535	0.0229	-0.103	0.007
Wh81+	-0.065	0.0297	-2.194	0.0444	-0.131	0.0002

Regression Statistics

Multiple R	0.9434
R Square	0.8901
Adjusted R Square	0.7487
Standard Error	1.9339
Observations	17

Analysis of Variance

	df	*Sum of Squares*	*Mean Square*	*F*	*Significance F*
Regress	9	211.96	23.551	6.2969	0.012
Residud	7	26.181	3.7401		
Total	16	238.14			

	Coefficients	*Standard Error*	*t Statistic*	*P-value*	*wer 95%*	*pper 95%*
Intercep	8.0037	7.5291	1.063	0.3035	-9.8	25.807
AnR	0.0544	0.0584	0.9303	0.3661	-0.084	0.1926
SpR	0.0149	0.0222	0.6701	0.5123	-0.038	0.0673
HmR	-0.052	0.0533	-0.972	0.3456	-0.178	0.0743
WhB1+	-0.195	0.0573	-3.402	0.0036	-0.33	-0.059
Sp81+	-0.04	0.0159	-2.505	0.0234	-0.077	-0.002
Hm82+	0.0242	0.016	1.5107	0.1504	-0.014	0.0621
An81+	-0.03	0.0159	-1.923	0.0725	-0.068	0.007
Dt88+	0.1255	0.0327	3.8431	0.0014	0.0483	0.2027
Tur2+	1.2116	0.3481	3.4807	0.0031	0.3885	2.0348

The depletion of the stocks of mullets is determined by the reduction of the surfaca area of the near shore lakes, and their pollution from industry. This concerns practically all Black Sea countries. The almost complete disappearance of bonito end blue fish elong the Bulgarian, Romanian and Ukrainian coasts, also confirms a change for the worst in the western pert of the Black See.

The remaining fish species (thornback-ray; sting-ray: striped mullet, etc.) are not subject to commercial fishery, but they have a substantial importance for the fish component of the ecosystem, being predetors or competitors for food resources of all heavily exploited fish species. This also influences the stock dynamics of the latter, and therefore has to be kept in mind whan assessing their "optimum" (allowable) catches. The lack of regular ichthyological research for these species does not permit formal stock assessments. For the time being, stocks can be estimated approximately by trawl surveys using the standard scheme. This would enable a more complete understanding of the interrelationships between the most abundant species of the ichthyopopulation in tha ecosystem which would make the forecest of the year class strength more precise, which would be of great significance for commercial fish spacias with a short lifa span.

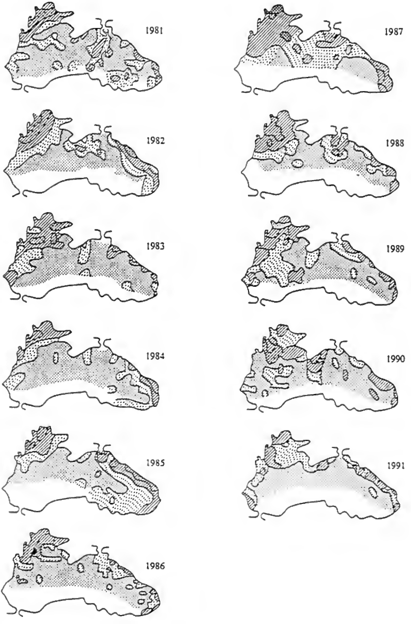


FIGURE 36. Distribution of the anchovy offspring in July-August 1981-1991

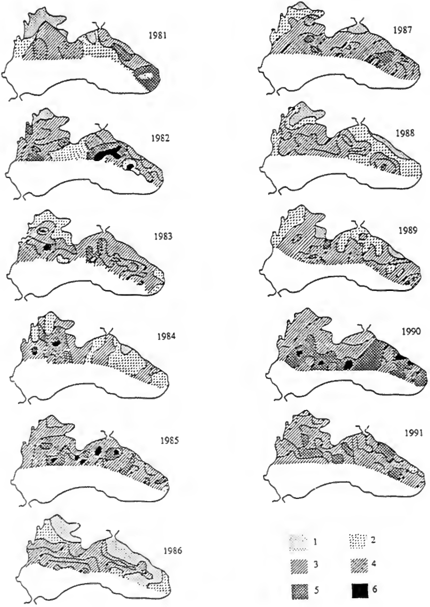


FIGURE 37. Distribution of sprat offspring in April-May 1981-1991 (in numbers/m^2) (from Arkhipov, 1993):
1: 0-10; 2: 11-100; 3: 101-1000; 4: 1001-10000; 5: 10001-100000; 6: >100000

V. ENVIRONMENTAL MANAGEMENT OF FISH RESOURCES IN THE BLACK SEA AND THEIR RATIONAL EXPLOITATION

The results of Black Sea fish stock assessments conducted over the past 25-45 years were juxteposed with more than 40 factors raveeling the changes that have occurred in the environment. As a result a number of regularities permitting the elaboration of a fishery strategy were established, with a view to sustainable utilisation of fish resources.

As it is well known, the problem of redressing the ecological balance in the basin lies at the root of all national and international programs and conventions: e.g., the "Convention on the protection of the Black Sea against pollution" (1992); "Government declaration" (Odessa, 1993); GEF; NATO TU-Black Sea; EROS-2000; Co-operative Marine Science Programme; CoMSBlack; Delta Danube Programme; GEF Danube River Basin, etc.

For solving the problems of fishery management, a Joint Fishery Commission was founded which has to plan concrete measures for rational exploitation of Black Sea fish resources.

A large number of obstacles arose during the development of the project "ENVIRONMENTAL MANAGEMENT OF FISH RESOURCES IN THE BLACK SEA AND THEIR RATIONAL EXPLOITATION". In our opinion, the representatives of the Black Sea countries in the mentioned Commission will also be faced with most of them. For this reason when specifying their particular action plans they ought to address the following problems:

- Standardize the values of population parameters (catch age composition, age of sex maturation, definite age, etc.) of the commercially valuable fish species. We consider it of high priority to prepare appropriate manuals for fish ageing aiming at standardizing the results of biological research. In order to use the historical data of every country, size-age keys are required for the particular fish species.
- Renovation of statistical data collection for the catch amounts and the fishing effort applied (by countries and fleets).
- Standardizing the methods of fish stock assessments in relation to the available biological and fishery information for the different fish species.

At present there is a large amount of data being collected at national levels. However, although national trends are analysed, detailed and theoretically substantiated analysis of regional data will further be impeded unless the mentioned above deficiencies are not surmounted. Furthermore, the available scientific information is interrupted by a lack of biological and fishery data for certain periods pointed to in the report. In the last 5-6 post-communist years after the transition to market economics was attempted, there has been a lack of good fishery statistics. These have to be considerably improved, especially in the former socialist countries and the data set expanded to include fishing effort. Information that was difficult to obtain has to be supplied where possible. For this reason, the coordination between the research Institutes and the corresponding State Institutions responsible for management and control of the biological resources, has to be improved. All this would facilitate further more an ecosystem approach to fish resources management.

According to our investigations the fish stock depletion in the Black Sea is due to the complex influence of various factors, dominant among them being overexploitation and the outburst of the new ctenophore *Mnemiopsis leidyi*, the latter having changed to a great extent the trophic interrelationships between the organisms in the Black Sea ecosystem. All this necessitates the applying of new approaches when suggesting the annual catches by species, and requires an account of the current state of the environment. In this connection, the Joint Fishery Commission ought to solve the following important problems:

1. **Migrating fish**

    1.1 Apportionment of the annual quotas by countries.
    1.2 Determinetion of regulatory measures for the different fish species and International control and surveillance of fishing by all Black Sea countries.

2. **Anadromous fish**

    2.1 Apportionmant of the annual quotas by countries
    2.2 Determination of the regulatory measures for the different fish species.

Solving of all these problems probably will need to be carried out in conformity with international maritime law (The Law of tha Saa, Tha Regime for High-Saas Fisheries (Status and Prospects, United Nations - New York, 1992), but in all cases the good will of all Black Sea States will be needed for the more rapid and effective protection of the fish populations in the basin. This concerns to the same degree the remaining intergovernmental conventions, especially that relating to the protection of Black Sea against pollution. Only by the common efforts of all Black Sea States, es well es of those from the Danube Basin, will the presarvetion of species' biodiversity for the fish population and thair sustainable utilisation by the commarcial fishery be possible.

VI. REFERENCES

Acera A., 1955. The cycla of inorganic phosphorus in the Bosphorus end its biologicel investigetions. *Int.Commn.Sci.Explor.of the Medit.*, Moneco.

Acere A., 19B5. The Bleck See turbot. T.S. Besbakanlic. Davlat planlama taskilati, 1-19.

Alaav Yu.G., 1957. Horsa mackeral (*Trachurus*) of tha Soviat seas. Tr. Sevastopol. Biol.St., 9: 167-212. In Russian.

Alaav Yu.G., 1959. On the reproduction of the southern populetion of the horse mackerel in the western erees of Black Sea. Tr. Sevastopol. Biol.St., 12: 270-285. In Russian.

Aleksendrov A.I., 1927. Anchovies in tha Saa o f Azov and Black Sea, their origin and taxonomic status. Tr.Kartch Fish Farm.St., 1, 1-3.

Alexandrova K., 1964. Particularities in the growth of *Mugil auratus* Risso along the Bulgerian coast of the Black Sea. In Bulgerian. Bulletin de l'Institut de Pisciculture et des Pêcharias, V. IV, 237-252.

Alexandrova K., 1967. Mullets in the lekes along the Bulgerien Black Saa coast. Proceedings of the Reseerch Institute of Fisharies and Ocanography-Varna, V. VIII, 263-293. In Bulgarian.

Alaxendrove K., 1973. Tha catch of mullats along the Bulgarian coest of the Bleck Sea end its effact on the stocks. Proceedings of tha Instituta of Oceanography and Fisheries, V. XII, 133-143. In Bulgarian.

Altukhov Yu.P. end Apekin V.S., 1963. Serologicel enelysis of tha "small" and "larga" form of the horse meckerel in the Bleck Sea. Vopr.Ichthiol., 3 (1): 39-50. In Russian.

Altukhov Yu.P. and Michalav Yu.A., 1964. Differances batween the "smell" end "lerge" form of the horsa mackerel of the Black See, esteblished by the characteristics of the callular thermel stability. Tr.AzTcherNIRO, 22: 23-29. In Russien.

Ambroz A.P., 1954. Distribution end fishery of tha Black Sea horsa mackaral. Tr.VNIRO, V. 28, 113-125. In Russian.

Ambroz A.P., 1955. Maturation and fecundity of Black Sea enchovy during 1952 end 1953. Tr.AzTcharNIRO, 16, 461-467. In Russien.

Ambroz A.P. end Kiriljuk M.M., 1979. Sturgeons (Acipenceridee). *In* monogrephy Living resources of Bleck See. Neukove Dumke. Kiev. In Russian.

Arkhipov A.G., 1993. Estimation of abundance and paculiaritias of distribution of the commercial fishes in the eerly ontogeny. Vopr.Ichthiol., 33 (4), 511-522. In Russian.

Artyomov A.G end Tcheshchin A.K., 19B2. Assessment of anchovy biomess epplying hydro - acoustic methods. Fish. Farm., N 12, 45-79.

Atanasova V., Velkova V. end Menasieve S., 1995. Multiennuel dynemics of plenkton in conditions of the entropoganic autrophication of tha Bulgarian aquatory of the Black Sea (in press, personal communication).

Bakun A., 1990. Globel climete chenge end intensificetion of coestel oceen upwelling. Scianca 247: 19B-201.

Bekun A., 1992. Global greanhouse effects, Multi-decadel wind trends, end potentiel impects on coastal palegic fish populetions. ICES Mar.Sci.Symp., 195:316-325.

Bletov A.S. end Ivanov V.A., 1992. Hydrology and Hydrodynemics of the Bleck Sea coastal zone. Neukove Dumke, Kiev, 242 pp. In Russien.

Bertalenffy L. Von, 1934. Untersuchungen uber die Gesetzlichkeiten des Wachstums. 1. Allgameina Grundlegen der Theorie. Roux' Arch. Entwcjlunggsmesh. Org. 131: 613-653.

Baverton R.J.H. and Holt S.H., 1956. A Review of methods for estimeting mortality rates in exploited fish populations, with speciel reference to sources of bies in cetch samplings. *Cons.Int.Explor.Mer.* Repp.et Procès-Verbaux, 14, 67 - 83.

Beverton R.J.H. and Holt S.H., 1957. On the dynamics of exploited fish populations. UK Min. Agric.Fish.Invest., Ser.2, N.19, 553 pp.

Boguslavsky S.G., Belyakov Yu.M and Gorov V.A., 1979. Peculiarities of the hydrology of the Black Sea. In Productivity of the Black Sea. Ed. by V.N Grese. Naukova dumka, Kiev. In Russian.

Berenheim D.Ya., 1960. Changeability of water level of Black Sea, Sea of Azov and river inflow. Tr.AzTcharNIRO, 22, 23 - 29. In Russian.

Bogdanova A., 1959. Water exchange through the Bosphorus and its role in mixing the Black Sea waters. Ir.S.B.S. In Russian.

Bogdanova A., 1969. Hydrology of the Bosphorus and the pre-Bosphorus region of the Black Sea. The water exchange through the Bosphorus and its repercussion on the hydrobiology and the biology of the Black Sea. Kiev. Naukova dumka, pp 3-12. In Russian.

Bodeanu N., 1979. Number of macrophytoplankton species in the Romanian coast of the Black Sea. In Productivity of the Black Sea. Ed. by V.N. Grese. Naukova dumka. Kiev. In Russian.

Caddy J.F., 1982. Some considerations relevant to the definition of shared stocks and their allocation between adjacent economic zones. *FAO Fish Circ.No.749* (Doc. FIRM/C 749) 40 p.

Caddy J.F., 1993. Reference points for fishery management: their potential application to straddling and highly migratory resources. FAO Fish.Depart. *FAO Fish.Circ.No.864*. Rome, 52 p.

Caddy J.F. and Csirke J., 1983. Approximation to sustainable yield for exploited and unexploited stocks. Oceanogr.Trp. 18(1):3-15.

Caddy J.F. and Sharp G.D., 1986. An ecological framework for marine fishery investigations. *FAO Fish.Tech.Pap.283*: 182 p.

Caddy J.F. and Griffiths R.C., 1990. A perspective on recent fishery-related events in the Black Sea. FAO Studies and Reviews, 63: 43-71.

Cautis I., 1966. Bul.Inst.Carc.Provact.Pisc., 25, 2:31-40.

Cautis I., 1971. Le sprat *Sprattus sprattus* L. du littoral roumein de la Mer Noire. Cercetari Marine 2: 51-73.

Cautis I., 1979. Biologie de la reproduction du chinchard de la Mer Noire. *In* E. Pora ed. - Le Chinchard de la Mer Noire (*Trachurus mediterraneus ponticus*), Etude monographique, Deuxième Partie, 461-478. In Romanian.

Cautis I. and Ionasku N., 1979. Structura populator de stavrid. *In* E. Pora ed. - Le Chinchard de la Mer Noire (*Trachurus mediterraneus ponticus*), Etude monographique, Deuxième Partie, 485-508. In Romanian.

Chashchin A.K., 1993. Present state of anchovy stock and the factors that determine it. Basic results from the comprehensive investigations of YugNIRO in the Azov-Black Sea basin, and in the World ocean, 76-78.

Cury P. and Roy C., 1989. Optimal environmental window and pelagic recruitment success in upwelling areas. *Can.J.Fish.Aquat.Sci.*, 46: 670-680.

Cushing D.H. and Dickson R.R., 1976. The biological response in the sea to climate change. Advance in Marine Biology, 14: 1-122.

Cushing D.H., 1979. Marine ecology. Food processing industry, Moskow, 288 pp. In Russian.

Darby C.D. and Flatman S., 1994. Virtual population analysis 3.1 user guide. *Info.Tech.Ser.*, MAFF Direct.Fish.Res., Lowestoft, 1:85 p.

Daskalov G., 1993. Essai de diagnostic du stock du sprat *Sprattus sprattus* L. dans la zone bulgare de la Mar Noire. Rapport de DEA, Univ. Aix-Marseille II, OSU (COM), 47 p.

Daskalov G. and Prodanov K., 1994. Variability in growth of sprat *Sprattus sprattus* L. off Bulgarian Black Sea coast with reference to the environmental changes in the Black Sea. Black Sea'94. Int.Conference Coll., reprints, 81-84.

Daskalov G. and Prodanov K., 1995. Stock assessment of sprat *Sprattus sprattus* L. off Bulgarian Black Sea coast using Length Cohort Analysis. *Rapp.Comm.int.Mer Medit.*, 34.

Demir M., 1955. Deniz Supiraleri (Cladocera) ve bunlarin Karadeniz sahil sularimiz ile Marmarada buldugumuz nevileri. Hidrobyiol.Mec., (A) 3(1): 37-47.

Demir M., 1961. Palemut-Toric (*Sarda sarda* Bloch) Yumurtalari Hakkinda. Hidrobyiol.Mec., (A) 5(1-2): 21-29.

Demir M. and Acara A., 1955. Biological and hydrological factors controlling the migration of the mackerel from the Black Sea to the Sea of Marmara. GFCM Proc. (3): 365-376.

Dimitrov P.S., Stoyanov A., Damirov E. and Solakov D., 1987. On the phenomenon of upwalling in the western part of the Bleck See and its connaction with the bloom of phytoplankton. Comptas-randus da l'Académia Bulgara des Sciancas, 40 (10): 127-130.

Dimitrov P.S. and Yanava A., 1992. On soma nagativa impact of upwelling phanomenon upon the Black Sea coastal ecosystam. Rap.Conf. "Ecological problems of tha Black Sea", Bourgas, 244-254. In Bulgarian.

Dobrovolov I. end Dobrovolova S., 1983. Biochemical polymorphism of tha Black Saa and Mediterranaan scads. Proc.of the Institute of Fisheries-Varna, XX, 101-107. In Bulgarian

Dobrovolov I., Dobrovolove S. and Prodenov K., 1984. Electroforatic enelyses of tha protains from Black Saa, and Atlantic's whiting (genus *Odontogadus*) min connection with their systamatic. Comptas-randus de l'Acedémia Bulgara des Sciancas, 37, No. 2.

Dobrovolov I. and Mikhailov K., 1991. About tha structure of anchovy's populations off Bulgarian Black Sea coast. Coll. of summaries from NSTS in Varna. *In* Ecology of tha Black Sea, 40-42. In Bulgarien.

Domashanko G.P., 1990. On fisharies importence and the current status of tha Black Sea surmullet investigations. Biological resources of the Black Sea. Collected papers of VNIRO, 134-139. In Russian.

Domashenko G.P. end Yurev G.S., 1978. Argument in favour in the sprat fishery in tha Black Sea. Tr.VNIRO, 128: 57-60. In Russian.

Domashenko G.P. and Aksalav O.I., 1990. Assassmant of tha total allowabla catch of Russian sturgaons for the North-western pert of the Black Sea. Biological resources of the Black Sae. Collected raprints of VNIRO, Moskow, 139-142. In Russian.

Domashanko G.P. and Sarobeba I.I., 1990. Sciantific basis of rational exploitation with respect to anchovy, sprat, whiting and spiny dogfish from the Black Sea. Biological resourcas of tha Black See. Collected reprints of VNIRO, Moskow, 142-145.

Erameev V.N. and Chudinovski T.V., 1990. Hydrobiology of the Black Sea. Applied Ecology of Saa Regions. The Black Saa, Kiav, 57-106. In Russian.

FAO, 1994. FAO Expart consultation on fisharies resaerch. Rome 12-15 April 1994: Smell pelegic fisharias. FAO Fish.Circ., No. 877: 53 p.

Fox W.W., 1970. An exponential yield modal for optimising exploited fish populations. *Amer.Fish.Bull.*, 99: 80-88.

Fox W.W., 1974. An overview of production modelling .Collect.Vol.Sci.Pap.ICCAT, 3: 142-156.

Gapishko A.I. and Malishev V.I., 1990. Calculating daily rations for sprat under natural conditions at tha tima of spawning and faeding migration. Biologicel resources in the Black Saa. Coll. raprints of VNIRO, 39-45. In Russian.

Georgiev Z.M. and Kolarov P., 1959. Abs. Bulletin of Bulgarian Academy of Sciencas.

Gaorgiev Z.M. and Kolarov P., 1962. On the migration and distribution of horsa mackarel (*Trachurus trachurus ponticus* Aleev) in the western part of Black Sea. Arbeiten des Zantralan Forschungsinstitutas fur Fishzught und Fisharei-Varna, II, 148-172. In Bulgarian.

Grese V.N. (ad)., 1979. Productivity of the Black Saa. Naukove dumka, Kiav. 388 pp. In Russian.

Gulland J.A. (ed)., 1965. Estimation of mortality retas. Annex to the report of tha Arctic Fisherias Working Group, Hamburg, ICES Doc.CM, 1965/3.

Gulland J.A., 1970. Tha fish rasourcas of tha ocean. *FAO Fish.Techn.Pap. No 97*, 1-425 (2-4, Mathods).

Gulland J.A. and Boarama L.K., 1973. Sciantific advica on catch lavels. US Fish and Wildlife. Fish.Bull., 71 (2) 325-335.

Hydrometaorology and hydrochemistry of tha saas of USSR, V.4. Black Saa. 1992. In Russian.

Ivanov L.S., 1964. Dynemics of the Black Saa mackaral (*Scomber scombrus* L.) stocks which migrate along Bulgerian coest end their reletion to the state of the stocks. Proceedings of tha Rasaarch Instituta of Fisharias and Ocaanography-Varna, V:65-91. In Bulgarian.

Ivanov L.S., 1966. On tha biology of tha mackaral of tha Black Saa (*Scomber scombrus* L.). Proceedings of the Research Institute of Fisherias and Oceanography-Varna, VII: 97-134. In Bulgerian.

Ivanov L.S., 1970. An attempt to determine tha mortelity rate of tha Black Saa mackaral (*Scombar scombrus* L.) caused by fishing and natural raasons. Proceedings of the Institute of Fisheries and Oceanography-Varna, X:75-90. In Bulgarian

Ivanov L.S., 1973. On tha reproduction of tha Bleck Saa mackerel (*Scomber scombrus* L.). Acta Biol.Jugosl., 5: 35-45.

Ivanov L.S., 1977. An asymmatric curva on the reproduction of fish populations. Proceedings of the Institute of Fisharies-Verne, XIV:7-15. In Bulgerian.

Ivanov L.S. and Karapetkova M., 1979. Dynamics of tha stocks of turbot (*Scophthalmus maeoticus* Pallas) in the Bulgerian shelf of the Black Sea and measuras for their rational utilization. I. Growth and mortelity retes, II. Stocks and reproduction. Hydrobiology, Sofia, 9:3-28. In Bulgarian.

Ivenov L.S. and Kolarov P., 1979. On tha ralations batwaan tha catchas of the Danuba shad (*Alosa kessleri pontica*) and the solar activity. Soc.Intar.Limnol. XIX Jubilaumstagung Donauforschung. Bulg.Acad.Wiss., 3B9-395.

Ivanov L.S., Kostyuchenko B. and Cautis I., 1979. Fundamantal laws of growth end nutrition, and tha corraletion batwaan nutrition and migration in fishas. In Productivity of the Black Saa. Naukova dumka. Kiev, 253-26B. In Russian.

Ivanov L.S., 19B3. Population parametars and limiting mathods of sprat *Sprattus sprattus* L. catchas in tha western Black Sea. Procaedings of the Institute of fisharias-Varna, XX, 7-46. In Bulgarian.

Ivanov L.S. and Beverton R.J.H., 19B5. Tha fisharies resourcas of tha Maditarranaan. Part two: Black Saa. FAO Studies and Reviews, 60: 135 pp.

Ivanov L.S., 19B9. On the ralation between catch, stock and production of Black Saa sprat (*Sprattus sprattus* L.). Hydrobiology, Sofia, 34:68-78. In Bulgarian.

Ivanov L.S., 1990. Dynamics and axploitation of Black Sea sprat stock. Annual report of the Institute of Fisharies-Varne, ms. In Bulgerien.

Ivanov L.S., 1991. Fluctuetions in the stocks of mackeral, bonito and bluafish against a beckground of tha eutrophication of the Black Sea. *In* Ecology and chemistry of the Black Sae. Scientific - tachnical conference - Varna. In Bulgarian.

Ivanov L.S. Direct observetion and back calculation growth of the Black Sea sprat (*Sprattus sprattus* L.) (manuscript). In Bulgerian.

Ivanov L. and Mikhailov K., 1991. On the relation between cetch, stock and production of the Black Sea anchovy (*Engraulis encrasicolus* Aleksandrov). Ocaanology, Sofia, 20, 16-25. In Bulgarian.

Ivenov L. and Mariniv G., 1992. Dynamics of the condition factor of the Bleck Sea sprat, *Sprattus sprattus* L. Procaedings of the Instituta of Oceanology-Verna, I: 110-11B. In Russien.

Ivanov L.S., 1994. A combined method for astimating sprat's stocks (*Sprattus sprattus* L.) in Bulgerian aquatory of tha Black See. Procaadings of the Institute of Fisheries - Varna, XXII, 105-116. In Bulgarian.

Ivanov L.S., 1995. The stocks of the sprat (*Sprattus sprattus* L.) in the Bulgarian zone of tha Bleck Sea for tha period 1945-1992. Procaedings of tha Institute of Fisheries - Varna, XXIII, 5-35. In Bulgarian.

Jones R., 1957. A much simplifiad version of the fish yiald aquation. Joint Meat. ICNAF (ICES) FAO, Doc.No P.21, Lisbon, 8 pp.

Jones R., 19B1. Tha use of length composition date in fish stock assessmant (with notes on VPA and cohort analysis). *FAO Fish.Circ.No 734*, 55 pp.

Jones R., 19B9. Towerds e general theory of population ragulation in marine teleosts. *J.Cons.int.Explor.Mer*, 45: 176-189.

Kalugina-Guthik, 1975. Black Sea phytobenthos. Naukova dumka, Kiev, 24B pp. In Russian.

Kalugina-Gutnik, 1979. Number of phytobenthos species in the Bleck Saa. *In* Productivity of Black Saa. Naukova dumka, Kiav, 388 pp.

Karapetkova M., 1964. Distribution and migration of the turbot (*Scophthalmus maeoticus*) elong Bulgarian Black Sea coest. Bulletin de l'Institut Zoologiqua et Musáe, 16:61-81. In Bulgarian.

Kerr S.R., 1974. Theory of size distribution in ecological communities. J.Fish.Res.Board Can., 31: 1859-1B62.

Kirnosova I.P., 1990. Growth perameters and mortality of spiny dogfish (*Squalus acanthias* L.) from tha Bleck Sea. Biological rasourcas of tha Black Sea. Coll. reprints of VNIRO, Moskow, 113-122. In Russien.

Kirnosova I.P., 1993. Stock conditions end alloweble catch of spiny dogfish in the Black Sea. Besic results from the comprahensiva investigetions of YugNIRO in the Azov-Black Sea besin, and in the World ocean, 69-76. In Russian.

Kirnosova I.P. and Shlyakhov V., 1988. Spiny dogfish (*Squalus acanthias*) abundance in the Black Sea. Vopr.Ichth. 28: 38-43.

Kolarov P., 1958. About the reasons determine the decreasing of the catches of A. k. pontica Eichw.Fish.Farm. 1:68. In Bulgarian.

Kolarov P., 1964. Some aspects of the changes in the age composition of the Black Sea shad (*Alosa kessleri pontica* Eichw.). Bulletin de l'Institut de Pisciculture et des Pêcheries-Varna, V:93-116. In Bulgarian.

Kolarov P., 1964. Size and age composition of bluefish (*Pomatomus saltatrix* L.) off the Bulgarian Black Sea coast. Bulletin de l'Institut de Pisciculture et des Pêcheries-Varna, IV:207-220.

Kolarov P., 1978. On certain changes in the population of *Alosa kessleri pontica* during its migration towards its reproduction areas. *In* Limnology of the Bulgarian sector of the Danube, Sofia, Bulgarian Academy of Sciences, 238-249.

Kolarov P., 1982. On the dynamics of the Black Sea shad (*Alosa kessleri pontica* Eichw.). Proceedings of the Institute of Fisheries-Varna, XIX: 35-57. In Bulgarian.

Kolarov P., 1986. Biological peculiarities and population dynamics of anadromous fishes. Dr.Sci.Theses, 419 pp. (in Bulgarian).

Konsulov A., 1986. Seasonal and annual dynamics of zooplankton in the Black Sea along the Bulgarian coast for 1974-1984. Oceanology, Sofia, 16:23-33. In Bulgarian.

Konsulov A., 1990. *Leucothea multicornis* Eschcholtz - new species for the Black Sea. Oceanology, Sofia,19:98-99. In Bulgarian.

Konsulov A., 1990. Daily vertical migration of zooplankton in the Bulgarian Black Sea coastal region. Oceanology, Sofia, 19:35-48. In Bulgarian.

Konsulov A., 1992. Zooplankton structure and distribution in the Bulgarian Black Sea coastal eutrophicated zone in summer 1991. *Rapp.Comm.Int.Mer Medit.*, 33:256-258.

Konsulov A. and Konsulova Tz., 1993. Biodiversity on the Black Sea plankton and benthos. National Biological Diversity Conservation Strategy, Sofia, 473-514. In Bulgarian and English.

Konsulova Tz., 1991. Ecological characteristics of Varna Bay (Black Sea) coastal ecosystems under summer "bloom conditions". Comptes rendus de l'Académie Bulgare des Sciences, 44/8, 113-117.

Konsulova Tz., 1993. Marine macrozoobenthic communities structure and ecological status in relation to some environmental factors. Comptes rendus de l'Académie Bulgare des Sciences, 46/5, 115-118.

Konovalov S. M., 1993. Impact of man on Black Sea ecosystem. *Rapp.Comm.Int.Mer Medit.*, 33:17 (m.s. 36 pp with 16 table - personal communication).

Kosswig C., 1955. Description of the Turkish marine fisheries. Hydrobiol.Res.Inst.Fac.Sci., Univ. Istanbul 5: 8 pp (mimeo).

Kutty M.K. and Quasim G.Z., 1965. The estimation of optimum age of exploitation and potential yield in fish populations. *J.Cons.Int.Explor.Mer*, V. 32, No 22: 191-202.

Laurec A. and Shephard J.G., 1983. On the analysis of catch and effort data. *J.Cons.Int. Explor.Mer*, No 40:81-84

Lipskaya N.Ya., 1960. Daily and seasonal feeding of Black Sea sprat (*Sprattus sprattus phalericus* Risso). Tr.Savest.Biol.St., 13: 190-203. In Russian.

Lukashev V.N., 1970. Method of calculating the least fishing mortality. Tr.VNIRO, 71:281-294. In Russian.

Lushnikova V.P. and Kirsonova I.P., 1990. Feeding and food requirements of thornbeck ray in the Black Sea. Coll. reprints of VNIRO, 58-63. In Russian.

Mann K.H., 1993. Physical oceanology, food chains, and fish stocks: a review. ICES *J.Mar.Sci.*, 50:105-119.

Mikhailov K. and Prodanov K., 1983. Approximate assessment of natural mortality rate of the anchovy (*Engraulis encresicholus ponticus* L.) off the Bulgarian Black Sea coast. Proceedings of the Institute of Fisheries-Varna, XX:173-182. In Bulgarian.

Mikhailov K. and Dobrovolov I., 1991. Morphologic and genetic analysis of the anchovy's populations along Bulgarian Black Sea coast. *In* Protection and rational exploitation of natural resources in the region of Varna, Varna Scientific Union: 108-116. In Bulgarian.

Mikhailov K., Andrianov A., Arkhipov A. and Lisovenko L., 1992. Estimetion of the enchovy spawning biomass in Bulgarian aquatory of Black See by Perkar's mathod. Procaedings of the Institute of Fisheries (in press).

Mikhailov K., 1992. Sex maturation of tha young-of-tha year anchovy, *Engraulis encrasicolus* (L.) in Varne Bey (Black See, Bulgerie) in August 1987. Proceadings of the Instituta of Ocaanology-Varna, I:172-173.

Mikhailov K. end Prodanov K., 1994. Preliminary date on the larval growth of Anchovy, *Engraulis encrasicolus* (L.) off the Bulgarian Black Sea coast. Black Saa'94. Int.Conference. Coll. reprints, 27-29.

Moncheva S., 1991. Eutrophication /phytoplankton blooms/ hypxia. International workshop on tha Black Saa, Varna, 30.09-04.10 1991.

Monchava S., 1992. Ecology of common Black Saa phytoplankton spacies undar tha influence of anthropogenic autrophication. Ph.D thesis. In Bulgarian.

Monchava S., Patrova-Keradjove V. and Palesov A., 1993. Harmful algel blooms along tha Bulgarian Black Saa coast and associatas fish and zoobenthothic mortelities. *Proc.of 6th Int.conf.toxic marine phytoplankton*, 18-22 Oct. 1993, Nantes, Franca.

Nacfhaaff A., 1939. The peculiarities in the migretions of *Scomber scombrus* L end *Serde sarde* Bloch. Travaux da la station ichthyologiqua-Sozopol, I:5-24.

Nikolow D., 1960. Biologia des Pelamiden *Sarda sarda* (Bloch) im Schwarzen Mear. Arbeitan des zentrelen Forschungsinstitutes fur Fischzucht und Fischarai - Varna, 3:17-55.

Numann W., 1956. Biologische Untersuchungan ubar die Stockar das Bosphorus, das Schwerzan Meeres und dar Mermera. Istenbul University. (B) 4:1.

Ovchinnikov I.M. and Popov Yu.I., 1987. Cold intermediete layer formation in the Black Sea. Ocaanology, AS URSS, 27(5): 239-248. In Russien.

Ovchinnikov I.M., Moskalanko L.V., Popov Yu.I., Prokopov O.I. and Sarditanko V.V., 1991. Some peculierities of hydrological conditions in tha Black Saa in the winter period. In Variability of tha Bleck See ecosystam. Moskow, Nauka, 345 pp. In Russian.

Peuly D. end Munro J.L., 1984. Once mora on growth comparisons of fish and invertebrates. Fishbyte 2(1):21.

Peterson I. and Wroblevski J.J., 1984. Mortality rata of fishas in the palagic ecosystem. *Cen.J.Fish.Aquat.Sci.*, 41:1117-1120.

Patipa T.S., 1991. Problams end davelopmant of tha studies on pelagic ecosystems in tha Black Sae. *In* The Variebility of the Bleck See ecosystem: naturel end enthropoganic factors, 336-345. Ed. by M.E. Vinogredov. Moskow, Neuka. In Russien.

Patrova-Karadjova V.J. and Apostolov E.M., 1988. Influanca of solar activity upon tha diatoms of Black Sea plankton. Rapp.et Procès-Verbaux des Réunions, CIESM, 31, 2.

Patrova-Karadjova V., 1992. Soler control upon the phytoplankton in tha Black Saa. Rapp.at Procès-Verbaux des Réunions, CIESM, 33, 265.

Pope J.G and Shaphard J.G., 1982. A simple method for consistent interpretation of catch-at-age data. *J.Cons.Int.Explor.Mer*, 40:176-184.

Popa J.G end Shaphard J.G., 1985. A comparison of the performence of verious mathods for tuning VPA's using effort data. *J.Cons.Int.Explor.Mer*, 42:129-151.

Prodanov K., 1979. Some data of whiting's biology and possibilities for increasing its catches. Fish. Farming, 6:19-21. In Bulgarian.

Prodanov K., 1980. Preliminary age- and growth data on Black Sea whiting, *Odontogadus merlangus euxinus* Nordmann, off Bulgarien Black Saa coast. Procaadings of tha Instituta of Fisharies-Varna, XVIII:121-134. In Bulgarian.

Prodanov K., 1982. An approximete estimetion of the optimum laval of exploitation of whiting's stocks. Proceedings of tha Institute of Fisheries-Varna, XIX:59-65. In Bulgarian.

Prodenov K., 1983. Raproduction, sax ratio and facundity of whiting (*Odontogadus merlangus euxinus* Nordmann) inhabiting the Bulgerien Black Saa coastal watars. Hydrobiology, Sofia, 18:23-34. In Bulgarian.

Prodanov K., 1983. Biometria and size/sexual variebility of meristic cherecteristics of Black Saa whiting. Procaadings of tha Instituta of Fisharies-Varna, XX:71-84. In Bulgarian.

Prodanov K. and Kolarov P., 1983. On the problem of tha retionel exploitetion of fish populetions. Proceedings of the Institute of Fisheries-Verne, XX:47-70. In Bulgarian.

Prodanov K., 1984. By-catch of whiting in Bulgarian trawl catchas of sprat. Fish.Ferming, 9:20-22. In Bulgarian.

Prodenov K., 1986. Condition of whiting's stock of tha western Black Sea area end off Bulgarian Black See coest. Hydrobiology, Sofie, 27:55-55.

Prodenov K. end Konsulov A., 1987. About some fectors determine the ebundence of 0+ yeer old fish (fingerlings) of whiting off Bulgarian Black Saa coast. Hydrobiology, Sofia, 30:44-55. In Bulgarian.

Prodanov K., 1989. On tha problem of datarmining tha optimum value of fishing mortelity coefficient (F_{opt}) end total allowabla catch (TAC). Hydrobiology, Sofia, 34, 79-90.

Prodanov K., 1991. An attampt at an approximete eveluetion of the everege stock of *Merlengius euxinus* L. in tha wastern part of the Black Saa during tha 1976-1984 pariod. Hydrobiology, Sofie, 36, 71-B4. In Bulgerien.

Prodanov K., 1991. A simple modal for tha influence of some fectors on the reproduction of fish populations. Hydrobiology, Sofia, 36:B4-93. In Bulgarian.

Prodanov K., Mikheilov K. and Deskelov G., 1991. On the problem of commerciel fishing influence on tha abundance and biomass of mackaral (*Scomber scombrus*), bonito *(Sarda sarda)* and bluafish (*Pomatomus saltrix*). Bleck See Symposium, Istenbul, 16-18 September 1991, Published by the Black Saa Foundation.

Prodanov K. end Deskelov G., 1992. Stock assassments of sprat (*Sprettus sprettus*) along Bulgarian Black Saa coast (1976-1990). Rapp.at Procès-Varbaux das Réunions, 33:305.

Prodanov K., Ivanov L. and Danchava K., 1993. Biodivarsity of tha ichthyofauna in the Bulgarian Bleck See weters. Netional Biologicel Diversity Conservetion Stretegy, Sofia, 547-566. In Bulgarian and English.

Prodenov K. and Deskelov G., 1995. Stock essessment of whiting (*Merlengius merlengus euxinus* Nordmann) along tha Bulgarian Bleck Sea coest during 1976-1993. Rapp.et Procès-Varbaux des Réunions. CIESM, 34.

Prodanov K., Mikheilov K., Deskelov G., Mexim K., Cheshchin A., Archipov A., Shlyekhov V. end Ozdemer E. Stock essessment and catch projection of horse mackerel (*Trachurus mediterraneus ponticus* Aleev) in reletion to tha environmental conditions during 1950-1993. First Intarnational CEOS meeting. Monterey, 05-09-1994, USA (manuscript).

Prodenov K., Mikheilov K., Deskelov G., Mexim K., Cheshchin A., Arkhipov A., Shlyekhov V. end Ozdemar E. Stock assessment of sprat (*Sprattus sprettus* L.) end whiting (*Merlengius merlengus euxinus* Nordmann) in tha wastarn part of Black Saa and Bulgarian Black Saa coast during 1957-1992 in relation to some netural and enthropogenic fectors. In Durand, M.H., R. Mendelssohn, Ph. Curry, C. Roy, D. Peuly (eds). Local vs. global changes in upwalling systems. Ed. ORSTOM (in press).

Ress T.S., 1987. Present notions ebout texonomic composition and chenges in ichthiophaune of tha Bleck Saa. Vopr.Ichthyol., 27, No. 2, 179-187. In Russian.

Rickar W.E., 1975. Computetion end interpratation of biological statistics of fish populetions. *Bull.Fish.Res.Bd.Can.*, 191:382 pp.

Rozhdestvensky A.V., 1954. The role of Denube for formetion of the Bleck Sea selinity. Tr.Morsk.Biol.St.-Varna, 18: 1-20. In Bulgarian.

Shepherd J.G., 1982. A family of ganaral production curves for exploited populations. Mathamatical Bioscienca, 59:77-93.

Shepherd J.G., 1994. Extended survivors enalysis: en improved method for the enalysis of catch-at-aga data and CPUE data. ICES W.P. 22 pp. (mimeo).

Shepherd J.G. and Derby C.D. Combinetion of recruit indices by weighted everages using RTC3: A user's guide MAFF Diract. Fish.Res., Lowestoft (manuscript).

Shulmen G.E. end Urdenko S.Yu., 1989. Fish productivity of the Bleck See. Neukova dumke, Kiav, 165 pp.

Sperre P., 1989. Introduction to tropicel fish stock assessment. *FAO Fish.Tech.Pep. No. 306*, 1, 337 pp.

Shlyakhov V.A., Cheshchin A. end Korkosh N.I., 1990. Fishing intensity and dynamics of the Black Sea anchovy stock. Coll. raprint of VNIRO, 80-92. In Russien.

Shlyekhov V.A. end Akselav O.I., 1993. Stock condition and reproduction efficient of Russien sturgeon in the north-western pert of Black Sea. Basic results from the comprehensive investigetions of YugNIRO in the Azov-Bleck See besin, end in the World ocean, 7B-B3. In Russian.

Sorokin Yu.I., 1982. The Bleck Sea: Neture, Resources, Nauke, Moskow, 216 pp. In Russien.

Stoyanov S., 1960. Tha stata of the stock of pontic sprat caught along the Bulgarian Black Saa coast in the periods 1945-1950 and 1955-1959. Arbaitan das zantralan Forschungsinstitutas fur Fischzught und Fischerai-Varna, III: 1-39. In Bulgarian.

Stoyanov S., 1965. Dynamics of the Black Sea sprat stock (*Sprattus sprattus sulinus* Antipa). Proceedings of the Research Institute of Fisharias and Ocaanography-Varna, VI:21-48. In Bulgarian.

Stoyanov S., 1966. Raproduction and modalling of tha Black Saa sprat stock (*Sprattus sprattus sulinus* Antipa). Procaedings of tha Instituta of Fisharias and Ocaanography-Varna, VII:135-157. In Bulgarian.

Stoyanov S., 1967. Biological charactaristics of tha anchovy (*Engraulis encrasicholus ponticus* Aleks.) caught off the Bulgarian Black Sea coast in 1961-1966. Proceedings of tha Instituta of Fisheries and Ocaanography-Varna, VIII: 5-38. In Bulgarian.

Stoyanov S., 1978. On the reproduction of Black Sea sprat and thair control. FAO, Rap.sur les pêchas, 204:105-110.

Stoyanov S., 1980. Stock-recruitment relationships in Black Sea sprat (*Sprattus sprattus sulinus* Antipa). Comptas randus da l'Académia Bulgara das Sciences, 33 (8): 1107-1109.

Stoyanov S., 1980. On tha long-tarm prognosis of Black Saa sprat raproduction. Comptes randus da l'Académie Bulgara des Sciancas, 33 (9):1223-1225.

Ulltang O., 1980. Factors affecting tha reaction of palagic fish stocks to exploitation and raquiring a naw approach to assessmant and managamant. Rapp.at Procès-Varbaux des Réunions. CIEM 177: 489-504.

Vinogradov M.E., Shushkina E.A., Musaeva E.I. and Sorokolit P.Yu., 1989. Ctenophora Mnamiopsis laidyi (*A. Agassis*) (*Ctenophora: Lobata*) - naw sattlars in tha Black Saa. Oceanology, Acad.Sci. USSR, 29 2, 293-299. In Russian.

Vinogradov M.E., Sapozhnikov V.V. and Shushkina E.A., 1992. Tha Black Sea Ecosystam, 110 pp. In Russian.

Vinogradova L.A. and Vassilava V.N., 1992. Tha dynamics of tha long standing and modalling of tha Black Sea north-wastern part coastal waters acosystam stata. Hydromataoizdat, Sankt Patarburg. In Russian.

Vollenweidar R.A., 1976. Advances in defining critical loading levels for phosphorus in lake euthrophication. Mem.Inst.Ital.Idrob., 33:53-83.

Zaika V.E. and Sergaava N.G., 1991. Diurnal variations in populations structura and vartical distribution of jallyfishes *Mnemiopsis mcCradyi Mayer* (Ctanophora) in the Black Sea. Gidrobiol.Jurnal, 27, No. 2, 15-19. In Russian.

Zaitzav Yu.P., 1993. Impacts of autrophication on the Black Saa fauna. *In* Fisharies and anvironmantal studies in tha Black Saa system, 63-85 pp. FAO Studias and Reviews, 64.

APPENDIX

In this appendix are given as an example all calculations for sprat stock assessments by different methods. Similar estimations were also made for the other fish spacies.

SPRAT STOCK ASSESSMENTS

SEP31.CSV

Separable analysis
from 1974 to 1993 on ages 0 to 4
with Terminal F of 150 on age 2 and Terminal S of 1.000

Initial sum of squared residuals was 639.529 and
final sum of squared residuals is 54.386 after 113 iterations

Matrix of Residuals

Years Ages	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83
0/1	2.194	-1.607	-1.285	1.491	2.102	1.209	-0.33	-0.301	-0.698
1/2	0.081	-0.616	-0.3	-0.539	-0.532	-0.799	0.004	-0.457	1.043
2/3	-0.044	0.745	0.361	-0.366	-0.483	0.151	0.234	0.367	0.163
3/4	-1.278	-0.171	0.218	0.626	0.542	-0.179	-0.383	-0.201	-1.173
TOT	0.001	0	0	0	0	0	0	-0.001	-0.001
WTS	1	1	1	1	1	1	1	1	1

Years	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92
0/1	-1.454	-1.319	-0.382	-0.408	-0.987	-1.567	0.839	0.541	2.398
1/2	0.817	0.388	0.802	-0.159	0.335	1.197	0.386	-1.052	0.515
2/3	0.002	-0.007	-0.066	-0.31	0.201	-0.206	-0.514	0.212	-0.294
3/4	-0.074	0.353	-0.526	1.179	-0.29	0.071	0.322	0.356	-1.286
TOT	-0.001	-0.001	-0.001	0	0	0	0	0	0
WTS	1	1	1	1	1	1	1	1	1

Fishing Mortalities (F)

	1974	1975	1976	1977	1978	1979	1980	1981	1982
F-value:	0.0109	0.0135	0.0296	0.0825	0.2087	0.5306	0.5763	0.8187	0.4631

F-values

Selection-at-age (S)

	0	1	2	3	4
S-value	0.0041	0.6458	1	1.0705	1

1

Run title 1993

At 25/12/1991 8 48

SPRAT STOCK ASSESSMENTS

SEP31.CSV

Separable analysis
from 1974 to 1993 on ages 0 to 4
with Terminal F of 150 on age 2 and Terminal S of 1.000

Initial sum of squared residuals was 639 529 and
final sum of squared residuals is 54.386 after 113 iterations

Matrix of Residuals

Years Ages	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83
0/ 1	2.194	-1.607	-1.285	1.491	2.102	1.209	-0.33	-0.301	-0.698
1/ 2	0.081	-0.616	-0.3	-0.539	-0.532	-0.799	0.004	-0.457	1.043
2/ 3	-0.044	0.745	0.361	-0.366	-0.483	0.151	0.234	0.367	0.163
3/ 4	-1.278	-0.171	0.218	0.626	0.542	-0.179	-0.383	-0.201	-1.173
TOT	0.001	0	0	0	0	0	0	-0.001	-0.001
WTS	1	1	1	1	1	1	1	1	1

Years	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92
0/ 1	-1.454	-1.319	-0.382	-0.408	-0.987	-1.567	0.839	0.541	2.398
1/ 2	0.817	0.388	0.802	-0.159	0.335	1.197	0.386	-1.052	0.515
2/ 3	0.002	-0.007	-0.066	-0.31	0.201	-0.206	-0.514	0.212	-0.294
3/ 4	-0.074	0.353	-0.526	1.179	-0.29	0.071	0.322	0.356	-1.286
TOT	-0.001	-0.001	-0.001	0	0	0	0	0	0
WTS	1	1	1	1	1	1	1	1	1

Fishing Mortalities (F)

	1974	1975	1976	1977	1978	1979	1980	1981	1982
F-value:	0.0109	0.0135	0.0296	0.0825	0.2087	0.5306	0.5763	0.8187	0.4631

F-values

Selection-at-age (S)

	0	1	2	3	4
S-value	0.0041	0.6458	1	1.0705	1

1

Run title 1993

At 25/12/1991 8 48

SEP31.CSV

Traditional vpa Terminal populations from weighted Separable populations

Fishing mortality residuals

YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982
AGE									
0	0.0003	0	-0.0001	0.0006	0.0032	0.0048	-0.001	0.0013	-0.0004
1	0.0047	-0.0024	-0.0047	-0.0313	-0.0559	-0.1596	-0.0214	-0.1273	0.3464
2	-0.0007	0.0075	0.0105	0.001	-0.0675	-0.0234	0.0597	-0.0825	0.0632
3	-0.0045	-0.0004	-0.0083	-0.0046	0.1188	0.0396	-0.1439	-0.1142	-0.2277
4	0	0.0165	0.0047	-0.0345	-0.1077	-0.0282	0.2532	0.0343	-0.0065

Fishing mortality residuals

YEAR	1984	1985	1986	1987	1988	1989	1990	1991	1992
AGE									
0	-0.0005	-0.0002	-0.0002	-0.0002	-0.0006	0.0019	0.0086	0.0028	-0.0004
1	0.1029	0.0746	-0.005	0.0409	0.1705	0.1308	-0.4825	0.0462	-0.1397
2	-0.0501	0.0439	-0.0705	0.0486	-0.0236	-0.252	-0.2958	0.0336	-0.0672
3	-0.0212	-0.0482	0.1328	-0.007	-0.0054	0.0977	0.1378	-0.1061	0.2867
4	0.021	-0.0685	0.0754	-0.1688	0.064	-0.1256	-0.4262	-0.0371	0.3501
1									

TUN521.CSV

Lowestoft VPA Version 3.1

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SPRAT 1993

CPUE data from file E:\LOWE\SP74\SP74TUN.DAT

Catch data for 20 years. 1974 to 1993. Ages 0 to 5.

Fleet	Firs year	Last year	First age	Last age
BG BOUR	1977	1993	0	4
USSR SM	1977	1993	0	4
USSR LAI	1977	1993	0	4
USSR RS	1978	1993	1	4

Disaggregated Qs
Log transformation
The final F is the (reciprocal variance-weighted) mean of the raised fleet F's.
No trend in Q (mean used)

Terminal Fs derived using L/S (without F shrinkage)

Tuning converged after 8 iterations

Regression weights

0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Oldest age F = 1.000*average of 2 younger ages.
1

Fishing mortalities

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0	0.001	0.001	0.001	0	0.007	0.014	0.004	0.001	0
1	0.336	0.168	0.189	0.251	0.301	0.737	0.737	0.167	0.081	0.069
2	0.215	0.327	0.183	0.385	0.178	0.699	1.396	0.352	0.254	0.153
3	0.428	0.179	0.775	0.266	0.222	1.219	2.156	0.122	1.281	0.128
4	0.322	0.253	0 479	0.326	0.2	0.959	1.776	0 237	0.767	0.14

Log catchability residuals

Fleet : BG BOURGAS

Age	1977	1978	1979	1980	1981	1982	1983
0	0.74	-1.07	0.94	-0.22	0.89	0 13	-0 45
1	-2.51	-1.23	-1	-0.33	-0.76	0.82	0.48
2	-0.54	-0.56	0 16	0.13	0.7	0.37	0.43
3	0.23	0.39	0.31	-0.04	1.03	0.1	0.16

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	-0.7	-1.29	-1.85	0.19	-2.03	1.95	2.02	1.56	0.58	-1.34
1	0.57	-0 14	-0 64	-0.3	-0.22	0 96	0.94	0.09	0	-0.73
2	-0.61	0.34	-0 7	0.15	-0.51	0.33	0.66	-0.2	-0.06	-0.24
3	-0 01	-0.41	0.15	-0.91	-0.56	-0.17	0.27	-0.2	0 68	0.16

TUN521.CSV

Fleet : USSR SMALL

Age	1977	1978	1979	1980	1981	1982	1983
0	0.59	-0.98	0.93	-0.12	1.07	-0.36	-1.31
1	-1.14	-0.36	-0.16	0.09	0.26	0.61	-0.18
2	-0.62	-0.38	-0.1	0.39	0.11	-0.1	-0.34
3	-1.1	-0.62	-1.25	-0.22	0.05	-1.42	-0.33

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	-1.89	-1.25	-0.69	-0.56	-2.28	1.13	2.07	1.92	0.38	0.77
1	-0.37	-0.69	-0.63	-0.21	-0.18	0.47	0.66	0.46	-0.14	0.18
2	-0.86	-0.52	-1.18	-0.29	-1.22	0.29	1.22	1.15	0.9	0.26
3	-0.05	-1.9	0.46	-0.92	-0.82	0.91	1.63	-0.18	2.51	-0.31

Fleet : USSR LARGE

Age	1977	1978	1979	1980	1981	1982	1983
0	0.75	-0.93	1.16	0.02	0.98	-0.07	-1.35
1	-0.98	-0.31	0.06	0.24	0.16	0.9	-0.22
2	-0.46	-0.33	0.13	0.54	0.01	0.19	-0.38
3	-0.94	-0.57	-1.03	-0.08	-0.04	-1.13	-0.36

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	-1.89	-1.02	-0.48	-0.51	-2.14	0.88	1.82	1.91	0.38	0.47
1	-0.37	-0.45	-0.43	-0.17	-0.03	0.22	0.41	0.45	-0.14	-0.12
2	-0.86	-0.28	-0.98	-0.24	-1.07	0.04	0.97	1.14	0.9	-0.04
3	-0.05	-1.66	0.66	-0.88	-0.68	0.66	1.38	-0.18	2.51	-0.61

Fleet : USSR RS

Age	1977	1978	1979	1980	1981	1982	1983
0	No data for this fleet at this age						
1	99.99	0.06	0.39	0.9	0.35	0.57	-0.14
2	99.99	0.05	0.47	1.22	0.21	-0.13	-0.3
3	99.99	-0.2	-0.69	0.59	0.14	-1.48	-0.28

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	No data for this fleet at this age									
1	0.11	-0.82	0.7	0.46	-0.87	-0.1	0	-0.28	-0.57	0.46
2	-0.38	-0.65	0.15	0.39	-1.92	-0.28	0.56	0.41	0.49	0.55
3	0.43	-2.04	1.79	-0.25	-1.52	0.34	0.97	-0.89	2.09	-0.03

TUN521.CSV

SUMMARY STATISTICS FOR AGE 0

Fleet	Pred. log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	-11.25	1.223	0.0001	0.0019	5.77E-02	8.28E-02	-11.249	0.339
2	-10.82	1.215	0.0002	0.0002	1.34E-01	7.60E-02	-10.825	0.337
3	-10.31	1.124	0	0.0003	1.09E-01	7.19E-02	-10.306	0.312
4	No data for this fleet at this age							

Fbar	Sigma(i	Sigma(e:	Sigma(o	Variance ratio
0	0.684	0.645	0.684	0.889

SUMMARY STATISTICS FOR AGE 1

Fleet	Pred. log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	-5.99	0.595	0.0105	0.143	3.23E-02	4.00E-02	-5.987	0.165
2	-5.54	0.392	0.0412	0.0577	3.59E-02	2.53E-02	-5.541	0.109
3	-5.02	0.326	0.0026	0.0783	1.11E-02	2.23E-02	-5.022	0.091
4	-12.82	0.477	0	0.0436	-3.78E-02	3.23E-02	-12.82	0.133

Fbar	Sigma(i	Sigma(e:	Sigma(o	Variance ratio
0.069	0.208	0.201	0.208	0.93

SUMMARY STATISTICS FOR AGE 2

Fleet	Pred. log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	-5.47	0.378	0.0177	0.1941	-1.27E-02	2.58E-02	-5.467	0.105
2	-5.39	0.712	0.0478	0.1175	9.11E-02	4.29E-02	-5.392	0.197
3	-4.87	0.634	0.0031	0.1595	6.63E-02	4.01E-02	-4.873	0.176
4	-12.68	0.654	0	0.0881	2.35E-02	4.60E-02	-12.677	0.182

Fbar	Sigma(i	Sigma(e:	Sigma(o	Variance ratio
0.153	0.269	0.174	0.269	0.416

SUMMARY STATISTICS FOR AGE 3

Fleet	Pred log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	-5.75	0.408	0.0134	0.1095	-5.68E-03	2.80E-02	-5.749	0.113
2	-5.3	1.052	0.0525	0.174	1.41E-01	6.26E-02	-5.298	0.292
3	-4.78	0.977	0.0034	0.2362	1.16E-01	6.02E-02	-4.779	0.271
4	-12.58	1.09	0	0.1322	7.39E-02	7.47E-02	-12.578	0.304

Fbar	Sigma(i	Sigma(e:	Sigma(o	Variance ratio
0.128	0.337	0.154	0.337	0.209
1				

XSA521 CSV

Lowestoft VPA Version 3.1

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Extended Survivors Analysis

SPRAT 1993

CPUE data from file e:\lowe\sp74\sp74tun1.dat

Catch data for 16 years 1978 to 1993 Ages 0 to 5.

Fleet	Firs year	Last year	First age	Last age	Alpha	Beta
BG BOUR	1978	1993	1	4	0	1
USSR SM	1978	1993	1	4	0.25	0.83
USSR LAI	1978	1993	1	4	0	1
USSR RS	1978	1993	1	4	0.25	0.5
YS0	1980	1993	0	0	0	1

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability dependent on stock size for ages < 1

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 1

Catchability independent of age for ages >= 1

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 4 oldest ages.

S.E. of the mean to which the estimates are shrunk = .500

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 30 iterations

Total absolute residual between iterations
29 and 30 = .00012

ETUDES ET REVUES DU CGPM PUBLIEES
GFCM STUDIES AND REVIEWS ISSUED

1 Standardisation de méthodes d'étude biométrique et d'observation de clupéidés (en particulier de Sardina pilchardus) utilisées en biologie des pêches, Division des pêches de la FAO - 1957

1 Standardization of biometric and observation methods for Clupeidae (especially Sardina pilchardus) used in fisheries biology, FAO Fisheries Division - 1957

2 Le Chalutage en Méditerranée - Observations préliminaires sur les chaluts italiens, Division des pêches de la FAO - Septembre 1957

2 Mediterranean trawling - Preliminary observations in the study of Italian trawl nets, FAO Fisheries Division - September 1957

3 La pollution des eaux provoquée par les déversements des sucreries, Carlo Maldura et Paul Vivier - Avril 1958

3 Water pollution caused by wastes from sugar refineries, Carlo Maldura and Paul Vivier - April 1958

4 Filets tournants et coulissants en fibres synthétiques, Gerhard Klust - Septembre 1958

4 Ring nets made of synthetic fibres, Gerhard Klust - September 1958

5 La pisciculture dans les eaux intérieures des pays membres du CGPM, Secrétariat du CGPM - Février 1959

5 Inland water fisheries in the GFCM member countries, Secretariat of the GFCM - February 1959

6 Le chalutage en Méditerranée - Deuxième et troisième rapports, Division des pêches de la FAO - Mai 1959

6 Mediterranean trawling - Second and third reports, FAO Fisheries Division - May 1959

7 La technique des pêcheries dans les lagunes saumâtres, Ruggero de Angelis - Août 1959

7 Fishing installations in brackish lagoons, Ruggero de Angelis - August 1959

8 La situation de la pêche en Italie, en particulier dans le secteur de la distribution, Paolo Pagliazzi - Octobre 1959

8 Situation of the fishing industry in Italy, particularly regarding distribution, Paolo Pagliazzi - October 1959

9 Documentation graphique sur certains engins de pêche utilisés dans les lagunes littorales espagnoles, Fernando Lozano Cabo - Novembre 1959

9 Graphic documentation on some fishing gear used in Spanish coastal lagoons, Fernando Lozano Cabo - November 1959

10 Le chalutage en Méditerranée Quatrième rapport, J. Schärfe, Division des pêches de la FAO - Mars 1960

10 Mediterranean trawling - Fourth report, J. Schärfe, FAO Fisheries Division - March 1960

11 Le traitement du fond des étangs piscicoles et ses effets sur la productivité. La pisciculture dans divers pays européens, Alfred G. Wurtz - Juin 1960

11 Methods of treating the bottom of fish ponds and their effects on productivity. Fish culture in certain European countries, Alfred G. Wurtz - June 1960

12 Exploitation et description des lagunes saumâtres de la Méditerranée, Ruggero de Angelis - Août 1960

12 Mediterranean brackish water lagoons and their exploitation, Ruggero de Angelis - August 1960

13 Contrôle d'un chalut opérant entre deux eaux ou sur le fond et tiré par un seul bateau, J. Schärfe, Division des pêches de la FAO - Septembre 1960

13 A new method for "aimed" one-boat trawling in mid-water and on the bottom, J. Schärfe, FAO Fisheries Division - September 1960

14 Le chalutage en Méditerranée - Cinquième rapport, J. Schärfe, Division des pêches de la FAO - Mai 1961

14 Mediterranean trawling - Fifth report, J. Schärfe, FAO Fisheries Division - May 1961

15 La madrague sicilienne de course, Vito Fodera - Juillet 1961

15 The Sicilian tuna trap, Vito Fodera - July 1961

16 Influence de la température et de l'éclairement sur la distribution des crevettes des moyennes et grandes profondeurs, Walter Ghidalia et François Bourgois - August 1961

16 The influence of temperature and light on the distribution of shrimps in medium and great depths, Walter Ghidalia and François Bourgois - August 1961

17 L'amélioration des techniques de la pêche au feu, F. Bourgois et L. Farina, Experts de la FAO - Novembre 1961

17 Improvements of techniques for fishing with lights, F. Bourgois and L. Farina, FAO Experts - November 1961

18 L'élevage des huîtres en parcs flottants, M. Nikolic et I. Stojnic - Mars 1962

18 A sytem of oyster culture on floating shellfish parks, M. Nikolic and I. Stojnic - March 1962

19 Pêche au feu, Raimondo Sarà - Août 1962

19 Light fishing, Raimondo Sarà - August 1962

20 Réglementation en vigueur sur la pêche de la sardine en Méditerranée, Service d'études législatives de la FAO - Juillet 1963

20 Existing regulations for sardine fishing in the Mediterranean, FAO Legislation Research Branch - July 1963

21 Diagnoses démographiques sur les populations de poissons dans les cours d'eau à truites, R. Cuinat et R. Vibert - Octobre 1963

21 Demographic diagnosis on fish populations in trout streams, R. Cuinat and R. Vibert - October 1963

22 Dommages causés par les marsouins et autres animaux marins déprédateurs en Méditerranée, C. Ravel - Novembre 1963

22 Damage caused by porpoises and other other predatory marine animals in the Mediterranean, C. Ravel - November 1963

23 Etudes sur la sardine (Sardina pilchardus Walb.) et l'anchois (Engraulis encrasicholus L.) dans le golfe de Naples et sur leur comportement sous l'influence de la lumière artificielle, Olav Dragesund - Juin 1964

23 Studies on the sardine (Sardina pilchardus Walb.) and anchovy (Engraulis encrasicholus L.) in the Gulf of Naples and their behaviour in artificial light, Olav Dragesund - June 1964

24 Réglementations concernant certaines industries de transformation des produits des pêches maritimes dans les pays méditerranéens, D. Rémy - Septembre 1964

24 Regulations on certain sea food processing industries in Mediterranean countries - D. Rémy - September 1964

25 Sur la valeur des anneaux nets pour la détermination de l'âge des sardines (Sardina pilchardus Walb.), R. Muzinic - Décembre 1964

25 The value of sharp rings for the age determination of sardine (Sardina pilchardus Walb,.), R. Muzinic - December 1964

26 Revue critique des effets des détergents synthétiques sur la vie aquatique, R. Marchetti - Octobre 1965

26 Critical review of the effects of synthetic detergents on aquatic life. R. Marchetti - October 1965

27 Méthodes permettant d'économiser la main-d'oeuvre à bord des chalutiers méditerranéens, M. Ben-Yami - Novembre 1965

27 Labour-saving methods on board Mediterranean trawlers, M. Ben-Yami - November 1965

28 La distribution et la commercialisation du poisson en Sicile, G. Bombace - Novembre 1965

28 Preliminary report on fish distribution and marketing in Sicily, G. Bombace - November 1965

29 Réglementation sanitaire des mollusques, R. Coppini - Décembre 1965

29 Sanitary regulations for molluscs, R. Coppini - December 1965

30 L'élevage de la truite fario et de la truite arc-en-ciel dans les eaux à température très élevée, E.G. Calderon - Décembre 1965

30 The raising of brown trout and rainbow trout in water at high temperatures, E.G. Calderon - December 1965

30 (Suppl.1) Suite des études sur les possibilités de développement de la salmoniculture en eaux chaudes, E.G. Calderon - Novembre 1968

31 Mortalité initiale de la sardine dans les conditions expérimentales et mortalité due au marquage, R. Muzinic - Août 1966

31 Initial mortality of the sardine under experimental conditions and in the tagging work, R. Muzinic - August 1966

32 Study of hake (Merluccius merluccius L.) biology and population dynamics in the central Adriatic, S. Zupanovic - February 1968

33 Unités de stock de la sardine de la Méditerranée occidentale et de l'Adriatique, M.G. Larrañeta - Juin 1968

34 The system of currents in the Adriatic Sea, M. Zore-Armanda - July 1968

35 Investigations of mullet fisheries by beach seine on the U.A.R. Mediterranean coast, S. Zaky Rafail

Rehabilitation of the fisheries of an inland saline lake in the United Arab Republic, S. El Zarka

Variations annuelles des captures de mulet dans le lac de Varna, D. Morovic - Juillet/July 1968

36 Aquarium tagging experiments on sardines with anchor tags by the use of tricaine methane sulfonate, R. Muzinic - October 1968

37 Fishery of the green crab (Carcinus maenas L.) and soft crab cultivation in the lagoon of Venice, S. Varagnolo

Results obtained by geological charting of trawling grounds in the channels of the northern Adriatic, S. Alfierivic

Effects of fresh water and saturated sea-water brine on the survival of mussels, oysters and some epibionts on them, M. Hrs. Brenko and L. Igic

December 1968

38 The weight-length relationship of United Arab Republic Sardinella, A.M. El-Maghraby

Distribution et densité des oeufs de sardines (Sardina pilchardus Walb.) dans l'Adriatique centrale au cours de la saison 1965/66, J. Karlovac

Coincidence and alternation in Yugoslav pelagic fisheries, R. Muzinic

Février/February 1969

39 Selectivity of gillnets for Nile perch (Lates niloticus L.), R. Koura and A.A. Shaheen

Cod end mesh size effect on Italian otter trawl efficiency, R. Koura

February 1969

40 Studies on the life history of Adriatic sprat, N. and D. Zavodnik - March 1969

41 Note préliminaire à l'étude de la production primaire dans l'Adriatique centrale, T. Pucher-Petkovic

Long term observation of plankton fluctuation in the central Adriatic, T. Vucetic and T. Pucher-Petkovic

Relation between some factors affecting productivity and fish catch in the central Adriatic area, M. Buljan

Mars/March 1969

42 Long line Mediterranean fisheries studies west of Alexandria, S.Z. Rafail, W.L. Daoud and M.M. Hilal - July 1969

43 Marine resource of the Untied Arab Republic, A.A. Aleem - December 1969

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